BOTANY FOR BEGINNERS.

CHAPTER I.

How to begin—dissection of flowers. WILLOW:—Inflorescence and parts of the flower—incomplete flowers—flowers of one sex with no perianth. POPLAR:—Flowers of one sex with a perianth. ASH:—Buds—position of leaves—inflorescence, flower and fruit—flowers of both sexes without a perianth. ELM:—Flowers of both sexes with a single perianth.

IN studying a flower, the first thing to do is to look at it well, so as to get a good notion of its general form and appearance; and in proceeding to dissect it, the beginner must start with the idea that he has a machine made of several parts, more or less complicated, to pick to pieces. His object in thus dismembering the flower is to ascertain of what parts it is constructed, their number, their shape, in what manner they are pieced together, whether they are separate or joined together, what is their relative size and position in regard one to another, and so forth. When the student has carefully ascertained these points, he should, if possible, make drawings of what he sees—no matter if the sketches be rough, they will still be very useful, and errors can be corrected as he progresses. Having made

ıself familiar with the structure of one flower, another ›uld be taken, treated in the same way, and ultimately npared with that which was first studied, in order to · wherein lie the points of resemblance and of disaiilarity between them. No special instructions are eded for the general examination of the leaves, stem, ots, &c.; but when occasion demands, a few suggestions ll be given on these points.

A pocket magnifying glass, a penknife, and a couple needles, firmly mounted in handles, will be all the ›paratus absolutely required, though it will add much › the pupil's convenience if the magnifying glass be ıounted on a little stand, so as to allow of the use of oth hands in pulling the flower to pieces. An inexensive apparatus of the kind, made to carry in the ocket, is sold by Messrs. Matthews, Portugal Street, *incoln's Inn.* Very little practice will be required to able the pupil to "dissect" flowers sufficiently well to .in a good general idea of their conformation; this ›tained, it will be easy, if desired, to pursue the ıbject more fully.

To help the beginner in this matter we shall attempt, ›y the aid of woodcuts, to explain the conformation of ommon flowers, beginning with those of the simplest .onstruction and gradually advancing to those of greater .omplexity. When, by the aid of selected illustrations, we have put the pupil in the way of examining for himself and of recognising the principal variations in the conformation of flowers, he will the better be enabled to understand the general principles of floral construction, in themselves very interesting, and which, once mastered,

will render all the rest comparatively easy. A general knowledge of the work done in and by the parts of the flower is also absolutely essential to a young student, and lends a charm to the flower itself that those who only study its dry bones, so to speak, can never appreciate. But these cannot be understood till the alphabet of floral construction is thoroughly known.

With these few hints to start with, let us avail ourselves of the flower of the Willow, "Palms," as the country people call them. It is not too much to assume that a Willow is known to everyone likely to read these notes, and the most superficial observer cannot fail to have noticed that there are several kinds of Willow (*Salix*)—some are trees, others shrubs. It makes no difference, for our present purpose, which kind of Willow be taken. In early spring by every river's bank may be seen, in the full flush of beauty, bushes smothered with golden blossoms, redolent with spicy fragrance, melodious with the hum of bees. Not far off is pretty sure to be found a similar bush much more modestly caparisoned, its blossoms of a dull quaker-grey or pale olive-green, very pretty and graceful, but not so attractive as the one of which we have first spoken. These are Willows. The golden blossoms are really flowers, so are the grey ones; wherein lies the difference between the two will presently be made apparent. As one object of these notes is to foster a tendency to notice common things, we may remark that the flowers are here produced before the leaves—a fact to be noted; moreover, it serves to confirm our assertion that what we have called flowers

really are so, for it is obvious there are yet no leaves on the bush—what, then, can these be but flowers?

Let us remove one of the yellow flowers from the branch, or, better still, pick one up from the ground, and examine it with the glass, using the point of a knife or of a needle to separate its parts. What do we find? An oblong mass, made up of shaggy scales, beyond which protrude long threads, like pins with yellow heads

Fig. 1.—Male catkin of Willow. Natural size.

Fig. 2.—Male flower of Willow detached from the catkin. Enlarged.

(fig. 1). Now, with the knife, separate one of the little shaggy scales from its fellows, as carefully as possible. By preference, take a scale from a young or recently opened blossom, and from near the pointed end of the mass. Suppose this proceeding satisfactorily accomplished, the observer should have before him a little scale (fig. 2) generally shaggy, with long hairs, and within the

scale, attached to its very base, two or sometimes more of the pin-like threads before mentioned, and on one side of them a small greenish sticky knob—unfortunately not represented in the drawing. That's all we have to deal with in this case. In truth, we have here a flower of very simple construction indeed. The shaggy scale is called a *bract*, the pin-like threads are called *stamens*, the shaft of the pin is the *filament*, the yellow head is the *anther*, which by the way we may notice is divided by one deep long furrow into two halves, called lobes. Each lobe is marked by a similar long groove, but not quite so deep, and which marks the place where the anther will presently split. The anther contains a yellow dust-like powder, which falls in showers when the bush is shaken, escaping from the two chinks just mentioned. This powder is the *pollen*. The green knob is a *gland* secreting a honied juice.

The oblong mass, then, which we picked off the ground is not a single flower, but a mass of flowers. It is what is called an *inflorescence*. As we shall see by-and-by, the inflorescence is very different in different plants, and different names are applied to these variations. The particular inflorescence before us is called a *catkin*, and one distinguishing feature of a catkin lies in the fact that it does not long remain on the bough which bears it, but falls off very early; and this is the reason why we advised the pupil to pick up the catkin from the ground. He will the more readily remember the "deciduous" character of the catkin.

If now we pluck a branch from the grey-looking Willow—this time we shall have to pluck from the bush,

as we shall not find many blossoms on the ground—we shall find a similar oblong mass (fig. 3), a catkin in fact, with the same sort of scales or bracts; but these bracts do not in this case protect pin-like stamens, but a small flask-like body (fig. 4), supported on a short stalk. The

Fig. 3.—FEMALE CATKIN OF WILLOW. Natural size.

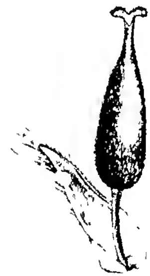

Fig. 4.—FEMALE FLOWER OF WILLOW. Enlarged.

neck of the flask tapers somewhat and divides into two spreading arms. This flask-like body is the *pistil*, in this case stalked and consisting of an *ovary* constituting the flask, a *style*, the neck surmounting the flask, and two *stigmas*, which are the divergent arms of the style.

Within the ovary are a number of very small *ovules*, which the inexperienced beginner will hardly be able to see, but which will ultimately make themselves sufficiently conspicuous as *seeds* covered with cottony hairs. In the Willow, then, we have two sorts of flowers, both of the simplest construction. We do not in the case of the Willow find both sorts of flowers on the same tree,

but on different trees. The one set of flowers (male flowers) furnish pollen from their anthers; the other (female flowers) yield seed from their pistil. But unless the pollen from the one kind of flower gain access to the stigma of the other kind of flower, no seeds will be formed. If, however, the wind convey the pollen from one flower to the other, or if bees or other insects visit first the highly scented stamen-flowers, and afterwards the pistil-flowers, they are pretty sure to scatter the pollen on to the stigmas of the latter, and the tiny "ovules," which the beginner will have difficulty in finding, will, in consequence, ripen into seeds which he cannot fail to see if he looks for them.

For comparison sake let the beginner examine the Poplar (*Pŏpulus*). He will find it in all main points like the Willow, but with its stamen-flowers (figs. 5, 6) more

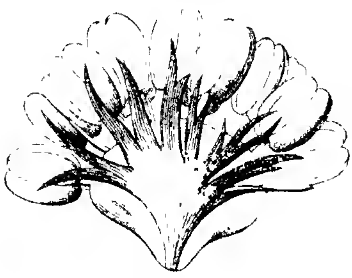

Fig 5.—MALE FLOWER OF POPLAR, from the outside, showing the slashed bract. Enlarged.

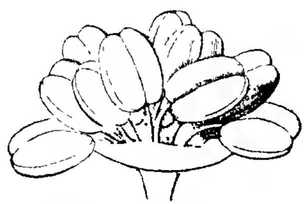

Fig. 6.—MALE FLOWER OF POPLAR, from the inside, showing the perianth and stamens. Enlarged.

complicated, first in that the bract is deeply cleft, and next in that the stamens are more numerous, and spring from a little cup-shaped *perianth,* placed within the

bract. In the Willow there was a bract but no calyx; in the Poplar there is a distinct "perianth." In two respects, then, we have an advance in complexity—in the increased number of the stamens and in the presence of a perianth or calyx. In the pistil-bearing trees just the same difference exists. The flask-shaped ovary is very like that of the Willow, but it rises from a cup, and not immediately from within the bract (fig. 7). When ripe it will split into two pieces—carpels (fig. 8) and expose the seeds. The seeds of the Poplar (fig. 9) are almost exactly similar to those of the Willow.

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Figs. 7 to 9.—7. FEMALE FLOWER OF POPLAR, with perianth and pistil. 8, Ripe fruit of Poplar splitting in two pieces; 9, Seed of Poplar. All enlarged.

We chose the Willow and the Poplar for our first illustration on account of their simple structure, and at the risk of being thought tiresome, we recommend the beginner to make sure that he understands the structure of those flowers before he proceeds further.

The Ash (*Fraxinus*) is usually in full bloom about the same time as the Willows and Poplars. Like the trees already mentioned, it produces its flowers before the leaves are unfolded During the winter the latter organs are carefully stowed away in those black leathery looking knobs which may be observed on the ends or sides of the branches, there we may leave them for the present, merely stating that the black knobs in question are the *buds*, and that their usual position is at the ends or on the sides of the branches. In the latter case they spring from the side of the branch in the angle formed between it and the leaf or leaf-stalk. This angle is technically called the *axil*;—a leaf-bud in this situation is thus spoken of as an *axillary bud*, while that which is placed at the end of a shoot is appropriately called *terminal* Although at this time our Ash shoot is leafless, it is yet easy to see where last year's leaves were placed, by reason of the very large horse-shoe shaped scars left after the fall of the leaf and which are placed on the sides of the twigs, and above which may be seen the axillary buds just alluded to (fig. 10, A). It is possible then from a glance at these scars to ascertain the position of the leaves, even in the absence of those organs. It will be observed on looking at an Ash twig that these scars occur in pairs; the scar on the one side is placed at the same level with a similar mark on the other side of the twig. Such an arrangement is described as *opposite*. The leaves then, and the buds axillary to those leaves, are, in the case of the A[illegible] *opposite*. If the beginner will examine a Willo[illegible] failing to procure a specimen, the figures given

he will see that the buds are not placed at the same level on different sides of the stem, but one above another; such an arrangement is spoken of as *alter-*

Fig 10.—TWIG OF ASH, showing terminal and axillary buds and inflorescence Nat size

nate. As the position of the leaves, or of the leaf-buds, is very serviceable in enabling foresters and gardeners to distinguish trees of various kinds one from the other, they should be carefully noted. As we go on we shall endeavour to show how such apparently trifling details are in reality very significant.

Passing now to the flowers of the Ash, we find them

grouped in bunches, emerging from the sides of the stem, each bunch opposite to its fellow (fig. 10). Indeed, as the bunches are really axillary to the leaves, and we have seen that the leaves are opposite, it follows that the bunches of flowers, the *inflorescences*, must have the same relative position as a rule, though there may be exceptional cases where the rule is apparently broken through. On comparing this inflorescence with the catkin of the Willow or Poplar the beginner will at once notice, that while in the latter case the flowers were densely crowded, in the Ash they are somewhat loosely

Fig 11.—Portion of INFLORESCENCE OF ASH, slightly magnified

massed (fig. 11); moreover, he will notice in the present case that each little flower has its own separate stalk, by

means of which it is attached to the main branch forming the axis or central stem of the inflorescence. In the Willow, at least in the case of the male flowers, each flower springs directly from the main axis without the intervention of any secondary stalk. In fact the inflorescence of the Ash is *branched*, that of the Willow is *simple*. It is not necessary to dwell any longer on the differences in the inflorescence of the plants we have selected as illustrations. We may have something more to say about them as we proceed.

Thanks to the loose branching character of the inflorescence in the Ash, the examination of the flowers becomes a very easy matter. It is simply necessary to separate a flower from its fellows with the point of a penknife, remembering always to take a young flower in preference to one that is older. Supposing the flower properly detached, its structure is seen to be of the simplest character (fig. 12); there is no bract, as in the Willow or Poplar, but there are stamens, and there is a pistil. The stamens are two in number, opposite, like the leaves, with short filaments or threads, and fat oblong anthers of a purple colour, each splitting by two long narrow chinks which open on the side of the anther farthest away from the pistil,—a fact worth noting, as we shall have to allude to its significance by-and-by. In the centre between the two stamens is the pistil, made up of an ovary so flattened as to fit in between the two stamens and surmounted by a thread or column—the style, and this again ending into a notch separating two little lobes or stigmas one from the other. The existence of these two stigmas may be taken as evidence

that the ovary which, as in the Willow figured at p. 6, fig. 4, appears simple, is in reality made up of two *carpels* joined together throughout the whole of their

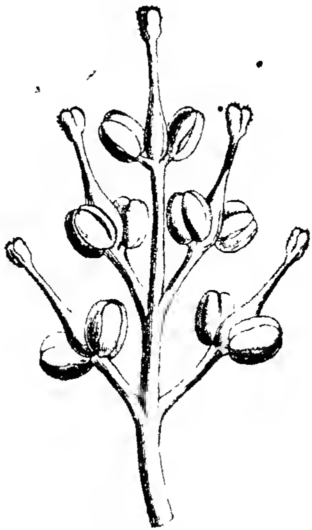

Fig. 12.—Five Flowers of the Ash, slightly enlarged, showing the stamens and pistil.

length with the exception of the stigmas. In the illustration of the fruit or seed-vessel of the Poplar at fig. 8, p. 8, the two carpels are seen separating one from the other, and thus demonstrating their mode of construction, but the Ash has not this obliging habit of revealing its structural peculiarities. The ovary of the Ash ripens into an oblong leafy seed-vessel, which every school-boy knows as the "key" (botanicè a *samara*), and which does not split when ripe. By cutting across the young ovary with a penknife and examining the cut with the

magnifying glass, the beginner may be able to make out that the interior of the ovary is divided by a partition into two halves, so that the section is not unlike a figure of ∞. Should his eye, however, not yet be sufficiently educated to observe this circumstance readily, he may content himself by counting the number of branches into which the style divides—in this case two—which indicates the number of carpels constituting the ovary. In the flower of Ash, then, we have neither bract nor perianth; in so far, it is simpler even than the Willow, but on the other hand it has both stamens and pistil in the same flower. In the Willow and Poplar the flowers are *unisexual*; and the flowers of different sexes are the produce of separate trees. In the Ash the flowers are for the most part, not invariably, *bisexual;* and the two sexes occur not only on the same tree but in the same flower.

In the Elm (*Ulmus*) the flowers occur before the leaves, as in all the previously-mentioned trees, and their structure is so simple that a very few words will suffice to explain their peculiarities. From within a membranous funnel-shaped perianth (fig. 13, A, B), the margin of which is divided by shallow notches into five rounded lobes, spring five stamens, of essentially the same structure as those of the Ash. The five notches indicate that the perianth is made up of five pieces partially united together. In the centre is a pistil, consisting of an ovary with two styles, and to which, therefore, what was said of the Ash applies equally. This pistil ripens into a membranous or winged seed-vessel (fig. 13, C), different

in outward shape, indeed, but otherwise very similar to that of the Ash.

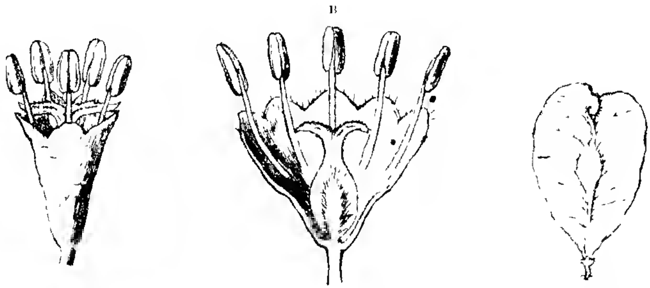

Fig. 13.—A, SINGLE FLOWER OF THE ELM, showing the perianth and the stamens; B, The same cut open, showing the origin of the stamens and the pistil; C, Seed-vessel of the Elm. A, B, magnified; C, natural size.

CHAPTER II.

Trees—bulbs—buds. TULIP:—Leaves—flower of both sexes with a double perianth forming a complete flower. HYACINTH:—Inflorescence—bulbs, artificial production of—flower-colour—separation or inseparation of parts—cohesion—adhesion.

THE examples we have hitherto chosen to illustrate the construction of flowers have all been furnished by trees. Willows, Poplars, Ash, and Elms have all woody stems of long duration. Their branches are but repetitions of the stem, and originated in the leaf-buds. These leaf-buds are for the most part invested by small scales, which gradually fall off as spring advances, and disclose the tender leaves nestling around the young shoots. By-and-by the shoots will lengthen, the leaves will acquire their full proportions, and the shoot, now green, will ultimately harden into a branch, which in its turn will repeat the process in another season.

The Tulip (*Tulipa*), which we select for our present illustration, is a plant of a somewhat different character. It affords a good illustration of what is termed a bulbous plant, the characteristic feature of which is, of course, the possession of a *bulb*. At first sight, no doubt, there appears to be but little in common with a bud and a

bulb, yet a little attention will show that there is a close resemblance between them. In a bud, as we have seen, we have generally a series of scales closely investing a number of tiny leaves springing from a rudimentary branch. In many buds we have not only leaves thus packed up, but flowers also, or it may so happen that the bud may consist of flowers only. Now let us look at a Tulip bulb—that of an Onion, a Hyacinth, a Lily, or a Narcissus, will answer the purpose equally well if a Tulip is not to be had, the difference in the bulbs of these plants being one of degree, not of kind. Proceeding to dismember our bulb, we come first to a series of scales (dry and thin in the case of the Tulip); within these are others, of a thick fleshy substance, while from the centre, as is very apparent in the spring, rises a stem with well developed leaves springing from its sides, and bearing at its top a flower. If this arrangement be compared with that of the bud of a tree, as before described, it will be seen that the correspondence is close. In essentials, at any rate, the bulb and the bud are identical. There is this difference, however, that in an ordinary tree or shrub the buds remain attached to the branches, while the bulb has an independent existence of its own. Ordinary buds are not wholly destitute of this property of leading an independent existence. Every time a gardener succeeds in striking a cutting, he is indebted for his success to the power that buds or young shoots have, under favourable conditions, of shifting for themselves. In many Ferns similar little buds are formed on the fronds, which, after a time, become detached, fall to the ground, and set up house-

keeping for themselves. The truth is, these bulbs contain in their fleshy scales a store of nourishment, which renders them, to a certain extent, independent of the parent plant or of the soil. This store is accumulated during the summer, and duly prepared for use, so that when in the following spring the season for growth recurs, every provision is made for a fair start. But although for a time, and to a certain extent, the bulb may thrive upon its own resources, the necessity for a supply of water greater than that furnished by its own tissues is soon experienced. This want is supplied through the agency of the roots, a whole tuft of which may be seen in Mr. Worthington Smith's drawing emerging from the base of the bulb (fig. 14, p. 21). The *roots* in this case consist merely of fine threads, and differ indeed in form and texture from the woody branching roots of the trees already mentioned, but they have the same office of imbibing from the moist soil the supply of water requisite for the full development of the plant. The stem, too, demands but little notice; it is an unbranched cylindrical column which will not harden like the shoot of a tree, but will shrivel and die when once the seed is fully ripe. Provident Nature, however, has already furnished another stem for a future season, as may be seen in the little bulb E at the base of the parent-bulb, and which is really an axillary bud, (see p. 9), destined in another year to play the same part as the parent bulb now does. The leaves too demand at present but little notice from us. It will be seen they are *alternate,* and that they spring directly from the stem, not being provided with any stalk. Botanists call such

a leaf *sessile.* Notice, too, that the leaves are not divided in any way; they are *simple* leaves, *i.e.*, in one piece, and *entire, i.e.*, not notched at the margin. We need not at this stage allude to their form further than to say that they are long, narrow, and sharp-pointed. It is worth noticing, however, that a number of fine lines run parallel with the edges of the leaf, so that it may be torn with a tolerably straight edge. These lines are the *ribs.* In an Elm, or in a Laurel leaf, these ribs are so arranged that on attempting to tear the leaf a jagged, irregular edge is left. We shall revert to this difference by-and-by.

Passing now to the flower, which is *solitary* on the end of the stem, we find it provided, as in the Poplar (figs 6, 7, pp. 7, 8), or the Elm (fig. 13, p 15), with a perianth, but this perianth is of a different character from those just alluded to. In the first place, it is brightly coloured, not green, then instead of being all in one piece it is here composed of six separate segments (a single not a double Tulip must of course be taken for examination). Moreover, if the flower be looked at before it is fully open—or on a dull day when it remains closed, it may be readily seen that three of the segments, though similar in form and colour to their companions, are distinctly outside them. In fact, just as the outer scales of the bulb overlap the inner ones, so do the three outer segments of the flower overlap the inner pieces. In the expanded blossom also this arrangement can easily be seen, and the beginner should now have had sufficient experience with the use of his tools, easily to detach the three outer from the three inner segments of the perianth.

Our Tulip flower, then, is more complicated than those we have previously dissected, inasmuch as it has a double perianth, or a perianth of two rows, the segments of both rows being of the same character, and only differing in position. Within the perianth are six stamens, each with its filament, or stalk, and its pollen-case, or anther. The pupil should notice their isolated character, and the fact that they spring from the centre of the flower immediately below the pistil (fig. 14, B). This last-mentioned organ is of oblong shape, divided by three long furrows into as many rounded lobes, and is surmounted by three *stigmas:* the ovary, in other words, is three-lobed, is destitute of a style, but has three *sessile* stigmas. The threefold appearance of the ovary, as we know already, indicates that the pistil is composed of three segments, which are called *carpels,* and which, unlike the stamens and perianth-segments, are combined. If we cut across the ovary, we shall see its threefold character apparent in the presence of three cavities corresponding to the lobes on the outside, and separated one from the other by three partitions answering to the furrows. The partitions meet in the centre, and to each angle of the triangle so formed are attached two rows of small white bodies, looking like the eggs of some insect, and which are the *ovules* or rudimentary seeds (D). It is hardly to be expected that the beginner can as yet do more than to satisfy himself of the existence of these bodies. Their form and structure are too obscure for him to make out without more practice than we can suppose him yet to have had. In the preceding illustrations, indeed, they are so small as readily to escape

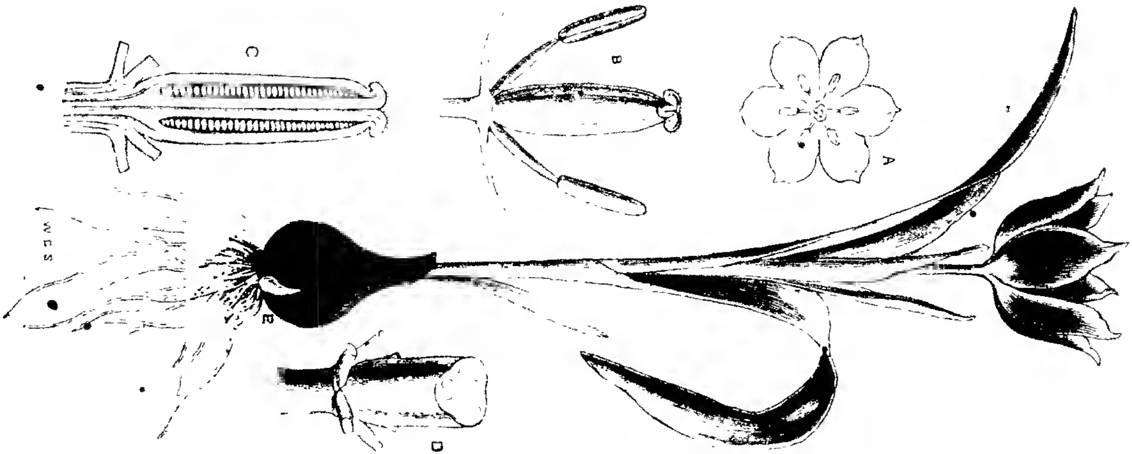

Fig. 14.—VAN THOL TULIP. A, Top view of flower; B, Section showing two stamens and the pistil; C, Longitudinal cut through the pistil, showing the placenta with the ovules; D, Transverse cut across the pistil, showing its three cavities, each with two rows of ovules, the six stamens are cut across below the anthers; E, The new bulb at the base of the parent bulb.

the beginner's notice. In the Tulip, however, he can, by cutting the ovary across (fig. 14, D) and lengthwise (fig. 14, C), see that they are very numerous and arranged in two rows. The angles to which they are attached constitute what is called the *placenta*. As we have neither ripe fruit nor seed before us, we need not say aught concerning them at present.

The flowers we have previously described have all been *incomplete*. The Willow had stamens only, or pistil only; the Poplar had a perianth enclosing stamens, and no pistil, or a perianth enclosing a pistil only; the Ash had stamens and pistil, but no perianth; the Elm had stamens and pistil, with a perianth of one row. Here in the Tulip we have, at length, what, for convenience sake, we call a *complete* flower—complete because it contains in the same flower both stamens and pistil enclosed within a double perianth. Notice further, that the parts of each series of this flower are about equal in size among themselves, that they are arranged in threes or sixes (twice three), and that they are all separate and uncombined, except in the case of the three carpels, which are united. The pupil who has followed us step by step, thus far, and has perfectly comprehended the structure of the flowers we have put before him, may rest assured that he has already made good progress in the comprehension of floral architecture.

The Hyacinth (*Hyacinthus*) is so similar to the Tulip in the essential characters of its roots, bulb, stem, and leaf, that much that was written of the one will apply equally to the other. It may be well, however, to notice that

whereas the Tulip stem bears a single flower at its extremity, and two or three leaves at its sides, the Hyacinth stem does not itself bear leaves, but supports a cluster of flowers, each separate flower having its own little stalk springing from the axil of a *bract*

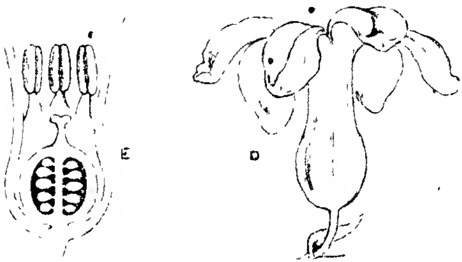

Fig. 15.—D, FLOWER OF A HYACINTH, represented in an erect position, and showing the stalk springing from the axil of a bract, and the six pieces of the perianth, "inseparate" below and forming a "tube." E, Section lengthwise through the centre of a flower, showing the position of the stamens, the ovules attached to the central placenta, the style, and stigmas.

and attaching it to the main stem, as shown at fig 15, D.

In speaking of the Tulip, we pointed out the provision for next year's growth in the little bulbs produced in the axil of one or more of the scales. A similar provision exists in the case of the Hyacinth, and, indeed, of other bulbs. Generally speaking, only a very small number of this second generation of bulbs are developed; many, indeed, are formed, but few grow to maturity. The Dutch bulb growers, however, with whom quantity as well as quality is a very important concern, manage to turn to account all the second generation of bulbs, and largely to increase their numbers. Their method of effecting this was described in the

columns of the *Gardeners' Chronicle* by Mr. Fortune some years since. Notches are cut in the base of the bulb (fig. 17), or a portion is scooped out (fig. 16), and, as a consequence of these injuries, a number of heretofore dormant buds start into life and growth; new ones are formed where ordinarily none would be seen, and in this manner one parent bulb is made to produce a large crop of little bulbs, which in due time grow into saleable commodities, having the characteristics of the parent Buds or bulbs formed in this unwonted manner, or in situations where ordinarily there are none to be seen, are called *adventitious*. The property of forming

Fig. 16.—Base of Hyacinth Bulb, scooped out to induce the formation of new bulbs.

these adventitious buds is a valuable one for the gardener in more plants than the Hyacinth.

The flower of the Hyacinth is, setting form and colour on one side, very similar to that of the Tulip. The beginner must please not consider this remark

17. PORTION OF THE BASE OF A HYACINTH BULB, notched so as to induce the development of "adventitious" bulbs.

as very Hibernian. He will not have made much progress in Botany before he finds that colour, with certain well marked exceptions, is botanically of comparatively little moment, and that form and size, unless associated with some other characteristic, are also, comparatively speaking, of minor consequence. We do not wish the beginner to despise either colour, form, or size, but we would caution him not to attach so much importance to them in botanical matters, as he would do in other things, and particularly not to rely upon them unless in association with other qualities.

Like the Tulip, the Hyacinth has a perianth of six pieces (fig. 15, D), but while in the Tulip the segments are all separate or *free*, in the Hyacinth they are partially or incompletely separated one from the other. In fact we have in the Hyacinth a bell-shaped flower, the *tube* of which consists of six segments not separated one from

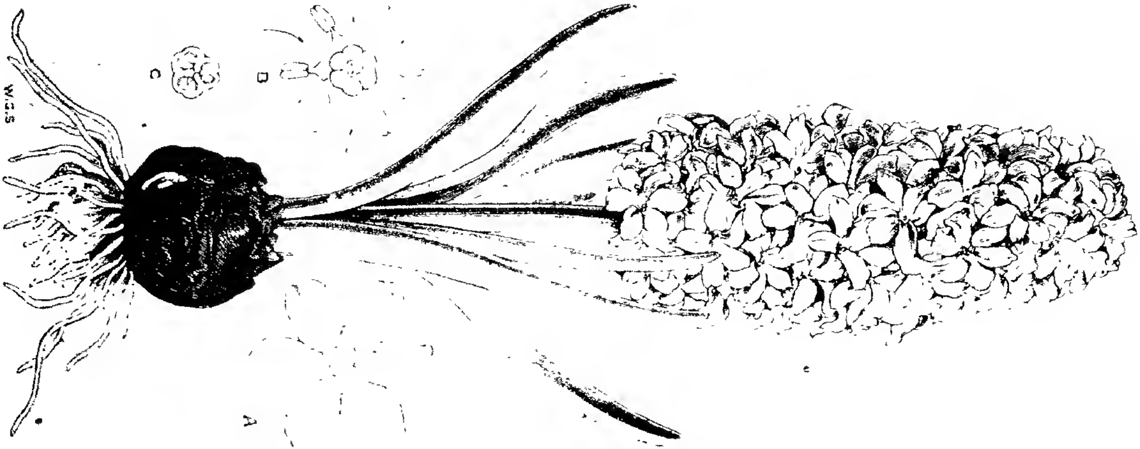

Fig. 18.—PLANT OF H[illegible] showing [illegible] A, Top [illegible] of flower [illegible] B, Diagram showing origin and relative position, of the stamens [illegible] the ovary, showing its three cavities enclosing the ovules.

the other; the *limb* of the flower constituting the margin of the bell being made up of the same six segments, but separate (fig. 15, D; fig. 18, A). The stamens have essentially the same structure as those of the Tulip, but instead of being *free*, they are only partially separated from the tube of the perianth (fig. 15, E). The pistil of the Hyacinth is almost precisely similar to that of the Tulip, and consists of three *inseparate* carpels, but while in the Tulip the style is absent and the stigmas large, in the Hyacinth the style is well developed and thread-like, and the stigmas small.

The Hyacinth affords us a good illustration of certain principles of floral construction most necessary to be understood. We allude to the independence or freedom of the several parts of the flower in some cases, as contrasted with their apparent combination in other instances. The six pieces of the perianth in the Hyacinth are combined below, or, more correctly speaking, they are not separated. In other words, the points of the pieces of the perianth are first formed, each separate from its neighbour. Growth near the points, however, soon ceases, and is resumed at the opposite end of the young flower, in such a manner that a tube, or cylinder, is formed, which is gradually pushed up as the draw-tube of a telescope might be if forced out from within. The six segments never become united together: they merely cease to be separated, and the tube of the flower consists of the lower *inseparate* pieces of the perianth. But more than this, the stamens are free above, but *inseparate* from the tube of the perianth below. They, too, begin life as independent stamens,

but the isolation ceases after a time, and in adult life they appear as if joined to the tube of the perianth. So in the pistil the three carpels are nearly *inseparate*, their extreme tips, the stigmas, are free; but the remaining portions never separate, at least till the seed-vessel is ripe.

Botanists speak of this apparent union either as *cohesion* or *adhesion*. By cohesion they mean the apparent union of parts of the same description one to the other; by *adhesion* they designate the apparent union of parts of different kinds; thus in the Hyacinth the six segments of the perianth are called *coherent*, while the six stamens apparently united to the perianth are spoken of as *adherent* to it. Now, as we have shown, there is really neither cohesion nor adhesion in this case, but simply an imperfect degree of separation, arising from an arrested or checked development. The terms cohesion and adhesion imply that parts originally separate become subsequently united; but this is not, in the generality of cases, a true expression of the state of affairs. Such a union does certainly take place sometimes, but very rarely. The processes to which the terms in question are usually applied, are, as above explained, those not of union but of imperfect separation. In future, then, we shall not employ these terms, cohesion and adhesion, as they convey erroneous ideas, but we have thought it necessary to explain them as they are in general use.

An apology is perhaps due for introducing a word as yet not in common use—*inseparate*. Our excuse is that it expresses the true condition of affairs, and that

the nearly allied word "inseparable" is already in common usage. With these explanations it is hoped the beginner will have no difficulty in understanding the sense in which the word is used.

CHAPTER III.

The APPLE:—Leaves, vernation and venation—stipule—inflorescence—thalamus—double perianth—calyx and corolla—adhesion. CHERRY:—Structure of flower. LILAC:—Principle of Compensation—Arrangement of leaves and of parts of flower—decussation, partially inseparate sepals, petals, stamens and carpels.

UNLIKE the trees previously mentioned, the Apple unfolds its flowers at or about the same time that the leaves expand. It is worth while, too, to notice the way in which the young leaves are rolled up, just as a plan or a roll of music might be. There are several modes in which the young leaves are rolled or folded in the bud, and, as is the case throughout all Creation, we shall find the mode of packing to be the best that could be contrived to avoid waste of space and secure the younger tissues from harm. The arrangement of leaves in the bud is technically called *vernation*, and the particular mode of vernation we have to deal with in the Apple is called *convolute*, or rolled. The beginner, too, cannot fail to notice that the leaves of the Apple are stalked, that they are *simple*, *i.e.*, in one piece, notched or *toothed* at the margins, downy, especially on the lower surface, traversed by a *midrib* continuous with the leaf-stalk, and from the sides of which pass

off others, and from these again others, till a network of fine ribs is produced, resembling the branches of a tree in miniature. Owing to this netted arrangement of the ribs or fibres of the leaf, it is not possible to tear it without leaving a jagged irregular edge. In the Tulip and Hyacinth the ribs are not netted, but nearly parallel, as previously explained. Now this disposition of the ribs of the leaf is a matter of some importance, because it enables us to distinguish at a glance the two principal subdivisions of flowering plants one from the other. The subdivision to which the Willow, Elm, Poplar, Ash, and Apple belong (*Dicotyledons*) has, subject to few exceptions, net-ribbed leaves. The subdivision to which the Tulip and Hyacinth belong (*Monocotyledons*) has almost invariably straight ribbed leaves. These are not the only differences between those two subdivisions. We shall point out several more by-and-by ; at present we merely call attention to the facts as they arise.

On either side of the base of the leaf-stalk of the Apple may be observed a small leafy segment, looking like a supplementary leaf or portion of a leaf. Such indeed it is ; but it is so different in dimensions that a different term has been applied to it,—viz., that of *stipule*. Note, then, that the Apple, like the Willow and Elm, has *stipulate* leaves, while the Ash, Tulip, and Hyacinth have *ex-stipulate* leaves.

Each flower in the case of the Apple is stalked, and the stalks are collected into a tuft at the end of the young shoots. In gardening operations, particularly pruning, it is of cardinal importance to notice the posi-

tion of the flower-buds, else for lack of knowledge the pruning-knife may verily be made to kill the goose

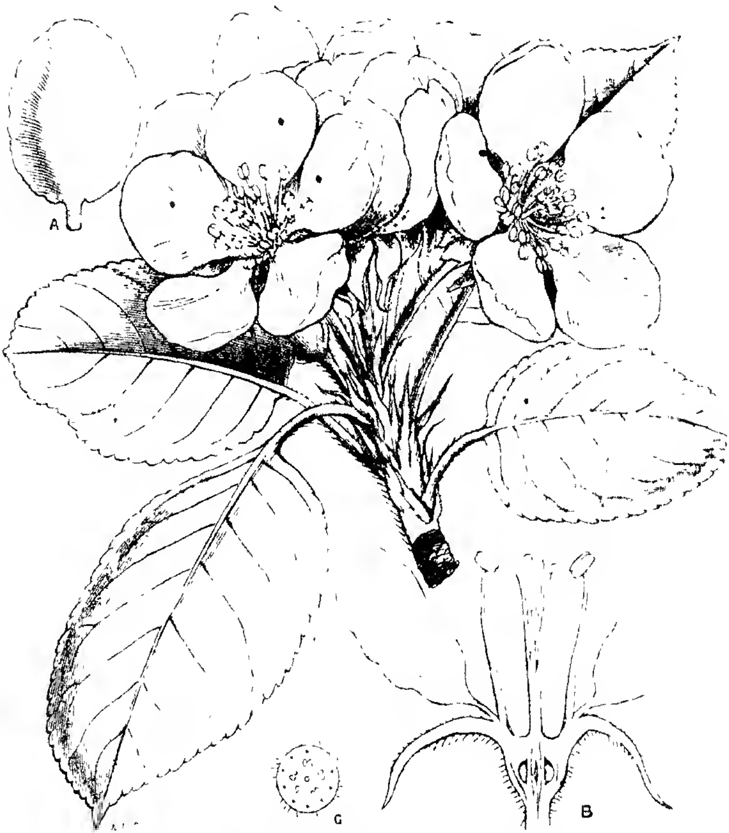

Fig 10.—LEAVES, STIPULES, AND INFLORESCENCE OF APPLE.—A, Petal, showing its stalk; B, Cut lengthwise through the flower; C, Cross cut through the receptacle.

that lays the golden eggs. The same remark applies to training and to the management of timber trees.

At the top of the flower-stalk the beginner will notice a swelling like the thick end of a club, a peg-top, a bell, or some other form according to the variety of Apple; at any rate in the Apple this portion of the flower-stalk is always swollen in some form or another. The top of the flower-stalk is of course the point whence the several parts of the flower spring, and therefore it plays a most important part in its construction. In botanical language it goes by the name of *thalamus;* popularly (and therefore with less precision) it may be called the receptacle. The receptacle in many flowers has no very particular outward characteristic. It may be distinguished by its position, and that is all, at least on superficial examination. For instance, in all the flowers we have previously examined there was no special feature to distinguish the thalamus. It was simply the starting point of the several parts of the flower, but in the Apple it is dilated and plainly visible. In some cases it is hollow or cup-shaped, in others it is rounded and dome-shaped, in others it is prolonged into a miniature shoot, around which the parts of the flower are disposed like leaves on a branch. It is easy to see from this how greatly the aspect of the flower depends on the form which the receptacle assumes.

At the top of the thalamus in the Apple we have the perianth, which here consists of two rows of segments differing in position and also in colour and form. In the case of the Tulip (fig.14) and Hyacinth (figs. 15—18), we had a perianth in two rows, but the members of each row were, save in relative position, alike. In the Apple, the outer perianth consists of five triangular leafy seg-

ments, bent downwards when the flower is expanded. Each segment also is sessile. The inner perianth consists of five, coloured, roundish segments, larger than the outer ones, provided with a little stalk, as shown at A (fig. 19), erect and overlapping one another in the bud, but spreading nearly horizontally in the expanded flower. When the perianth consists of two rows, thus differing in character, the outermost is called *calyx* and its segments *sepals*, the innermost is called *corolla* and its segments *petals*.

The sepals are usually more or less green and leafy; the petals are commonly more or less brightly coloured. The sepals serve to protect the flower in the bud; the petals, from their bright colours and perfume, attract insects, the visits of which are necessary in many cases to ensure the removal of the pollen from the anthers, and its deposition on to the stigma of another, or, perhaps more rarely of the same, flower. At any rate, the possession of a calyx and a corolla is a stride in advance in structural complexity over the flowers we have previously examined, and as such should be noted. Both sepals and petals are separate, and not really or apparently combined. The number of the sepals as of the petals is five; and it is here worthy of notice that plants with net-ribbed leaves usually have the parts of the flower in fives or fours, or double or treble those numbers, while plants with straight-veined leaves, like the Tulip and Hyacinth, have the parts of the flower grouped in threes, sixes, nines, twelves, and so on. The stamens in the case of the Apple are chiefly remarkable for their number; they are not easily counted,

and are hence termed *indefinite* in number; but it will generally be found that they are about 20 (four fives) When the flower is cut through, as at B (fig. 19, p. 32), there may be seen at the base of the stamens a yellow rim, which is called a *disc*, not clearly shown in the woodcut, and which indicates in this case the point of emergence of the stamens from the receptacle.

A cut lengthwise through the flower will also show that the ovary is concealed within the club-shaped end of the receptacle B, and not only concealed within it, but actually *adherent* to it. By *adhesion*, as already mentioned under the Hyacinth (p 28), the union of two or more parts of different character is designated. Where we have the ovaries joined to the receptacle, they are spoken of as *adherent* to it. This is a real case of adhesion, and not an apparent union arising from lack of separation. In the very earliest stages of the Apple blossom—when the flower is so small that the observer must have much practice and much patience before he can see its construction for himself—the ovaries, five in number, are entirely separate, but they very shortly become embedded in and adherent to the rapidly developing thalamus. The five styles of the Apple are free from one another above, but below they are *inseparate*, though, unlike the ovaries, they are free from the receptacle. The little knobs at the end of the styles are the stigmas. A cross cut through the receptacle below the sepals, as at C (fig. 19, p. 32), will show the five ovaries with their ovules, surrounded by the receptacle.

What we have said of the Apple applies for the most part to the Pear, the most important distinction between

them being, that in the latter the styles are free for their whole length. As the flower ripens into the fruit the

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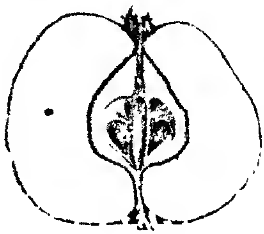


[illegible]

already swollen thalamus will become more and more swollen and fleshy—will form, in fact, the fruit of the Apple or Pear, *while the ovaries will be represented by* the core (probably a corruption of the French *cœur*, heart), and the ovules will have ripened into pips or seed.

Our main object in selecting the Apple as the subject of this illustration was to exemplify the phenomena of *adhesion* of the ovaries to the receptacle, and the dilatation of the latter, and as this is a point of great importance in more ways than one, it should be carefully studied, and to that end we advise the beginner to make

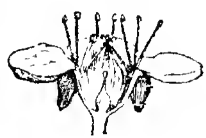


Fig. 22.—Flower of Cherry, cut through.

a cut lengthwise through a Cherry blossom, and to compare its structure with that of the Pear or Apple. They

are similar in most respects, but the thalamus in the Cherry, although hollow, (fig. 22) contracts no adhesion to the ovary (here solitary), which remains free in the centre of the cup. The beginner has only to imagine the consolidation of the cup and the ovary to understand the structure of the Apple or Pear. The fleshy edible portion of a Cherry is not the receptacle then, but is the ovary itself become fleshy externally, woody within, the woody "stone" enclosing the kernel or seed.

The Lilac (*Syringa*) is so common and so beautiful an ornament of our gardens in the spring of the year, that the beginner will have no difficulty in procuring a specimen wherewith to follow our description. For our present purpose it matters not which species or variety be chosen. It is a curious circumstance that the native country of our common Lilac is not known with certainty, but Hungary, Central Asia, and the Nepalese Himalaya, are known to be the sources of the other and less common kinds. Quaint old Parkinson tells us that the "Blew Pipe tree groweth in Arabia (as Matthiolus thinketh, that had it from Constantinople)." Judging from what we know of the climate of Arabia, it would seem very unlikely that so hot and dry a country should be the source of our hardy Lilac. We question, also, whether anyone now-a-days would know what the Pipe tree was, though in Parkinson's time it was called "of all in English the blew pipe tree. * * It is also," says he, "called Syringa [from the Greek *syrinx*, a pipe], because it commeth nearest unto those woods which from their pithy substance were made hollow into pipes."

Probably the trumpet-like form of the blossoms furnishes a better explanation of the name. The Lilacs are all shrubs or bushes, not making one main trunk like a tree, but having several, all of about the same dimensions, proceeding from near the root. Number here compensates for size, and as we would constantly wish principles to be borne in mind in reading these notes, so we take the opportunity, *en passant*, to point out to the beginner the universality of this principle of compensation throughout creation, and in accordance with which, if one part be large another is small, to preserve the balance, and so forth. The Lilacs, too, have the habit of sending up *suckers* from the root, or from those portions of the stem below the surface. These suckers differ in no material manner from other adventitious buds, except in their production below the ground. It is worth while also to note the rapidity with which the shoots of the Lilac are developed. In the course of a week or two after the buds begin to swell, shoots 5 or 6 inches long may be met with. The observer will find that the principal growth, in length at any rate, of the shoots of our trees and shrubs occurs in early spring, and within a comparatively short space of time, as if the tree made haste to "make its growth," as a gardener would say, in order that the tender shoots may be well consolidated or "ripened" by the summer's sun and light. For this ripening of the wood the French use the significant word *aoûté*, the heat and sun of August (Août) being especially favourable for the process.

If the beginner will examine these rapidly growing shoots, he will have no difficulty in seeing that the

growth in length of the shoots takes place mainly at their points. The shoots lengthen in consequence of the activity of the *growing point*, which forms, in this case, the apex or tip of the shoot. He can hardly fail to notice the regularity with which the stalked leaves come in pairs, one leaf of each pair *opposite* to the other, as before explained. Moreover, he will remark that the successive pairs of leaves cross one another at right angles, for instance, if the leaves in the lowest pair are directed to the right and to the left hand, the leaves of the pair next above are fore and aft. It is worth while attending to this easily observed fact, because precisely the same crossing or *decussation* takes place in the parts of the flower, where, however, it is less easily observed. This *opposite* and *decussate* arrangement is obvious enough in the inflorescence. The flower-cluster is made up of a great number of flowers, placed in pairs, the successive pairs crossing one another like the leaves.

The larger branches of the inflorescence have each a small leaf or bract at their base, but the smaller flower-stalks which immediately bear the flower have usually no bract at their base, or if present it is very minute. The flower of the Lilac is complete, with an inconspicuous thalamus and a double perianth, the outer or calyx consisting of four sepals *separate* at their tips, but *inseparate* below, and thus forming a shallow cup-shaped or bell-like tube; the inner perianth or corolla is four or five times as large as the calyx, lilac (or white) and sweetly scented. It is made up of four petals, inseparate below, and there forming a long tube or pipe (pipe-tree) separate above, and there constituting a four-pointed star, whose

rays when expanded are bent nearly at a right angle to the direction of the tube. This four-pointed star is the *limb* of the corolla, and with a little attention the pupil will see that its four segments *decussate* with those of the calyx just as the pairs of leaves do. Taking a single flower between finger and thumb of the left hand, let the pupil insert the point of his needle or pen-knife into the lower part of the corolla-tube, and with a rapid upward movement slit it up. By thus opening the flower (as at B, fig. 23) he will be enabled to see two stamens inseparate from the corolla-tube except as to their anthers. In consequence of this want of separation between the stamens and the corolla, when the one is pulled off the others go with it. This is a practical point worth attending to. In the Apple the petals may be removed one by one without detaching the stamens. In the Lilac, moreover, the stamens are fewer in number than the segments of the calyx or corolla, not a very common occurrence. With the aid of his magnifying-glass, if his unassisted eye be as yet unable to discern it, the beginner will see the pistil in the bottom of the calyx-tube, and more readily if he will first pull off the corolla. The small oblong greenish body is the ovary, which tapers above into a long thread or style, which again ends in two yellowish divisions — the stigmas. The fact that there are two of these stigmas, indicates, as before stated, that the pistil is made of two carpels inseparate throughout their whole length, except at the stigmas. A cross cut through the pistil will also show two cavities separated by a central partition, and

the seed-vessel when ripe will split into two somewhat woody pieces.

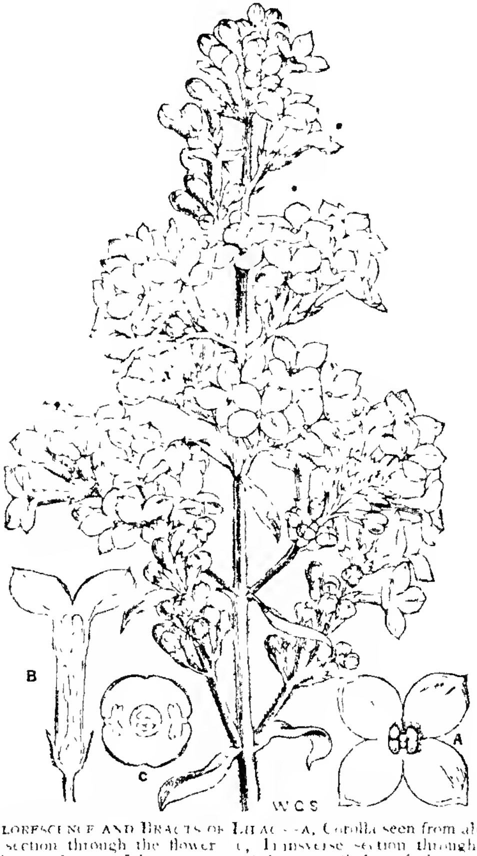


Fig. 23.—INFLORESCENCE AND BRACTS OF LILAC.—A, Corolla seen from above; B, Longitudinal section through the flower; C, Transverse section through the corolla, showing the attachment of the stamens and the two-celled pistil (diagrammatic).

It is hardly likely that the beginner will see very much resemblance between the Lilac and the Ash (see p. 13, fig. 12); nevertheless, botanists put them in

the same order. It may be well to point out some of the conspicuous points of resemblance between them, and the pupil will do well to find out for himself by comparison of actual specimens, or from an examination of the illustrations, wherein the differences consist between the two plants.

The leaves are opposite and decussate in the Lilac ; so they are in the Ash, though different in form. The flowers are arranged in a similar manner ; the stamens are two in the Lilac, so they are in the Ash ; the carpels are two in both, and in both the stamens and carpels are at right angles one to the other. True, in the common Ash there is no calyx and no corolla, but in another kind of Ash both calyx and corolla are present, and arranged crosswise just as in the Lilac. Moreover, in the internal and in the more minute parts of the flower (those organs which by reason of their importance to the life of the plant we call *essential*) such as the ovules or young seeds, the resemblance is complete.

The moral to be deduced from this is, don't trust to superficial appearances. There is no great resemblance superficially between the Lilac and the Ash, but essentially there is a close approximation. The showy corolla, in spite of all its beauty, is a less essential part of the organisation than other less gaily adorned parts on which the very life and perpetuity of the race depends. No uncommon case this in other organisms besides Lilacs and Ash trees. It may be added, in conclusion, that both Lilac and Ash belong to the same group as that of which the Olive forms the type, viz., *Oleaceæ*.

CHAPTER IV.

The WALLFLOWER:—Inflorescence—definite or indefinite forms of growth—structure of the flower—unequal growth of stamens—glands of the disc—their meaning and office. The LABURNUM:—Compound leaves—inflorescence—flower complete—irregular growth of petals—inseparation of stamens—papilionaceous corolla—legume—fertilisation of the flower by insects, how effected—suppression of parts.

OUR artist has drawn a Wallflower (*Cheiranthus*) in a stage which enables us to say something more of the *inflorescence* than we have hitherto done. It will be seen (fig. 24) that there is a cluster of flowers at the end of a shoot, each flower provided with its own separate little stalk. Such an inflorescence is technically called a *raceme*. But the fact we wish specially to call attention to is this, that while the topmost flowers are still in full bloom the lower ones have shed their petals and only the pods remain. Clearly, then, the lowermost flowers have been the first to open, while the youngest flowers, the latest in order of expansion, are at the end of the shoot. An inflorescence of this kind is called *indefinite*, whereas one in which the topmost flowers open first, and those lower down expand subsequently, is called *definite*. It matters not what form the inflorescence assumes—long or short, rounded or flat, simple or

branched, few or many-flowered — all the variations admit of being grouped under these two heads.

If the inflorescence be rounded or flat, like a Daisy (described and figured in a subsequent chapter), then it is the outermost flower that opens first in the case of indefinite inflorescence, the central one in the case of the definite arrangement. Of course the outermost and lowermost, or the innermost and topmost flowers mutually correspond. Suppose a coil of measuring tape rolled up to represent the rounded or flat-topped inflorescences; pull up the end, which is in the centre of the coil, and you would have the analogue of the long inflorescences. These two modes of growth, definite and indefinite, are well worth carefully noting, as they apply not only to the inflorescence, but to the branches, and indeed to every part of the plant. Sometimes the direction of growth is from above downwards (definite), at other times from below upwards (indefinite). It is easy to see how the whole form of the plant depends on this very simple circumstance; and, moreover, every thoughtful young gardener who has to prune fruit trees or roses, thin Grapes, take cuttings, or even cut flowers for a bouquet, will recognise how important it may be in some cases to have an accurate knowledge of this difference in the mode of growth, and to act on it. If, for instance, the top of the Wallflower be taken off, no more flowers are produced on that shoot; but if the central flower of a cluster of Roses be cut out, there will still be others left to cut and come again for if necessary.

Proceeding to pick our Wallflower to pieces (fig. 25,

p. 47) (a single Stock or a purple Rocket will answer the purpose as well, if a Wallflower is not at hand), the

Fig 24.—Inflorescence of Wallflower

beginner will notice that there are four free sepals, but that two of the four are placed at a slightly lower level than the other two, and have, moreover, a little pouch-

like projection at their base. Here, then, we have a calyx in two rows; outer row of two pouched sepals, inner row of two sepals destitute of pouch. Then comes the corolla of four free petals, arranged crosswise, one pair decussating (see p. 39) with the other, and each petal having a well-marked stalk or claw, and a broad limb nearly at right angles to the claw. This peculiar *cruciferous* condition of the corolla is very characteristic. Four stalked petals, placed crosswise, occur in the order *Cruciferæ* (cross-bearers), and in no other. Wallflower, Stock, Rocket, Cabbage, Turnip, Mustard, and a host of other ornamental or useful plants, belong to this cruciferous family, which may be recognised in a moment by the character just pointed out.

Within the four petals we come to six stamens, of unequal length, and on slightly different levels (D, fig. 25); in point of fact, we have two rows of stamens—an outer row of two short stamens opposite to the two lower pouched sepals, an inner row of four long stamens opposite to the four petals. The presence of six stamens, two short, four long, is almost as good a mark of *Cruciferæ* as the four stalked petals.

Each stamen has a filament or stalk and an anther at the top, which latter is two-lobed, each lobe splitting by a long chink to permit the escape of its contents, the dust-like substance called pollen. Pull the stamens away, which can be easily done, as they are free and not in union with either calyx or corolla, and there is left in the centre the pistil, in this case consisting of a long ovary which is two-celled (as shown at E, fig. 25), and which is surmounted by two stigmas. Should the beginner have

any doubt as to the two-celled character of the pistil, he has but to wait till the pod (C, fig. 25) is ripe, and then

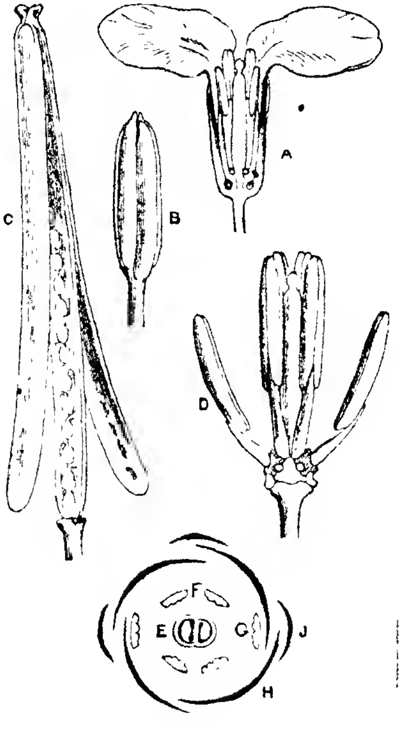


Fig. 25. WALLFLOWER.—A, Cut through the flower lengthwise; B, A flower-bud; C, A ripe pod splitting into two valves; D, Stamens and glands; E—H, Ground plan of flower.

he will readily see that the ripe pistil or pod splits into its two constituent parts from below upwards, and leaves in the centre the placenta with the ovules or seeds attached. In this flower, then, the parts are arranged

in twos or fours, two outer sepals, two inner sepals, four petals, two outer stamens, four inner ones, and a two-celled pistil. The arrangement of these parts is shown in a sort of plan at the lower part of the cut (fig. 25); J shows the position of one of the outer sepals, H of a petal, F of two long stamens, G of one of the short ones, and E is the pistil. Such ground plans are very useful to botanists, in enabling them to see at a glance the number and arrangement of the parts of any given flower. It may possibly strike the pupil that there is a sort of inconsistency in this flower, and that to ensure the proper harmony of proportion there should be two more short stamens to make up the outer quartette Perhaps also, if he be a stickler for proportion, he may say that two more cells should be added to the ovary. Supposing this to happen, the flower would have four sepals, in two rows of two each, four petals, eight stamens in two rows, and a four-celled pistil. Such a flower is supposititious. Nevertheless there are some grounds for the belief that some part at least of this supposition is correct, as sometimes flowers may be met with confirming the conjecture. If the observer will look at the base of the short stamens of the Wallflower, he will see some small bright green knobs or glands, as they are called, whose function it is to secrete honey-like fluid. They are shown in the cut (fig. 25) at A, and also at D. Now in various Crucifers the number and position of these glands vary, and from these and other circumstances, which it is, perhaps, premature to mention, botanists have arrived at the conclusion that these glands are the representatives of some, at least, of the missing organs. To this

it has been objected that the glands in question are not formed in the babyhood of the flower till after the other portions are developed, but this circumstance does not appear to us necessarily to militate against the notion just expressed. We cannot fully enter on this subject, as it is one more fitted for an advanced pupil; but we may say that there is an interest and a fascination about this sort of research—a sense of satisfaction at being permitted to pry into Nature's workshop and model-room—which the mere flower-gatherer never knows. Further we may add that to Mr. Worthington Smith, the delineator of most of the illustrations accompanying this series, botanists are indebted for one of the most plausible accounts of the structural meaning of these little green glands, whose office now is only to secrete honey.

The Laburnum (*Cytisus*), with its graceful drooping clusters of clear yellow blossoms, is so beautiful that it seems sacrilege to talk of "dissecting" it. But when the dissection reveals new beauties, unseen by the casual observer, and unfolds many means to one end, and that end the welfare of the species, it is clear that the sacrilege is rather with those who admire and pass by than with those who with equal, or greater admiration for the beautiful, yet seek, by something more than superficial glances, to ascertain its significance. Let us proceed to notice some of the main points in the structure of the Laburnum, and to call attention to the principles of plant construction they serve to illustrate. In all cases we presume the beginner to have followed us step by step, plant in hand; or, failing that, to have

made use of the woodcuts, and hence we are saved the necessity of much repetition.

In the Laburnum (fig. 26) we have a form of leaf different from any we have yet seen. It has a stalk with two little stipules at the base. So far there is nothing peculiar about it; but the pupil will notice at the upper end of the stalk what he might take to be three leaves, one central and one on either side. These three apparent leaves are really only segments of one leaf,—*leaflets* of a *compound leaf* as they are called. The blade of the leaf, instead of being in one piece, is here represented by three leaflets, each articulated to the stalk at a little joint, so that they may readily be separated. The Ash has a similar compound leaf, but the leaflets in that case are more numerous than three. The Rose affords another good example of a compound leaf (fig. 31, p. 58).

The inflorescence of the Laburnum is a raceme, the lowest flower opening first, though from the pendulous character of the raceme it would seem to be the uppermost flower which opened first. The flower has a double perianth, the outer row consisting of a cup-shaped calyx of five sepals inseparate except at their extreme tips. Notice also that the calyx is not quite regular in form, but a little larger on the lower side, D, E (fig. 27). Two of the tips or teeth are at the upper or back part of the flower, three others at the lower or front part. The inner perianth or corolla consists of five yellow petals, irregular in form. Thus at one side of the flower, that nearest to the branch or centre of the tree, the back of the flower, as it is called, we have one petal, marked A, larger than the rest, bent backwards and

Fig. 26. INFLORESCENCE OF LABURNUM

marked by purplish or brownish streaks in the centre.

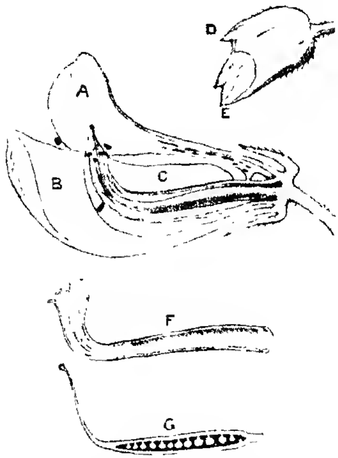


Fig 27 FLOWER OF LABURNUM seen in section and with its component parts detached. —A, Standard, B, Wing, C, Keel, enclosing pistil and stamens, D, Four-cleft calyx, with one of the lower segments, E, a little larger than the others, showing a tendency to be five-cleft, F, Longitudinal section of tubular stamen-sheath, G, Longitudinal section through pistil, showing ovules attached to the placenta.

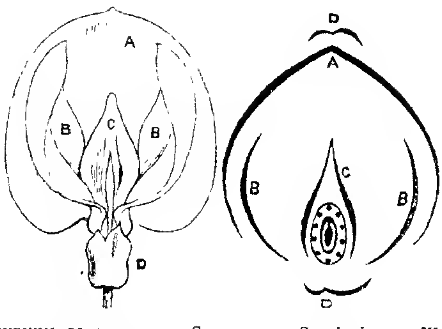


Fig. 28. LABURNUM, DIAGRAMMATIC SECTION —A, Standard, B, B, Wings, C, Keel, enclosing the stamens and pistil (with position of ovules), D, Calyx.

On each side there are two petals, B B, projecting hori-

zontally, with their edges directed upwards and downwards, not sideways, as usual, and each with a short stalk. In the front of the flower are two more oblong petals, C, with their edges in the same direction and coherent at their tips, so as to make a boat-like cavity. The two side petals and the two lower petals thus completely enclose the stamens and pistil, and if a bee or other insect visit the flower, bent on obtaining honey, he is first of all attracted by the perfume of the flower, then directed in his course by the large petal at the back with its purple stripes; having landed on the flower, he has to thrust his snout amongst the petals to get at the honey, and in so doing is pretty sure to brush out the pollen from the anthers.

The stamens of the Laburnum are ten in number, coherent below or inseparate so as to form a tube (fig. 27, F), which at its free end bears ten anthers. If a young flower-bud be opened it will be seen that five of the anthers are smaller than the others, though this irregularity of proportion is scarcely visible in the expanded flower. Within the tube of the stamens is the pistil (fig. 27, G), consisting of a single carpel tapering at one end into a style, which is bent upwards, and ends in a small stigma. If the busy bee, already referred to, after having ransacked one flower for its honey, and thereby become well dusted over with pollen, now visits another flower, attracted thereto by the perfume, and guided—nay, almost forced to go in a certain direction, owing to the peculiar arrangement of the parts of the flower, it will be seen that almost to a certainty he must come in contact with the upturned stigma and deposit

the pollen thereon, and thereby "set the fruit." Surely no clearer evidence of design could be wanted! The carpel, after being thus fertilised, will ripen into a pod like that of the Pea. In point of fact the Laburnum, though a tree, belongs to the same group as the Pea, Bean, Scarlet Runner, &c., a group for the most part characterised by the possession of compound leaves, *papilionaceous corollas*, and *legumes* or pods. A *papilio-*

Fig. 29. LEGUME of pod of Pea

naceous corolla is such a one as we have just described, an *irregular* five-petaled corolla, with one large petal at the back, sometimes called the *standard*, two side petals called the *wings*, and two front petals more or less united to form the *keel*. All the *Papilionaceæ* have such a corolla. The *legume* is a carpel, which when ripe splits into two valves, as any beginner may exemplify in the process of shelling Peas. Most of the *Papilionaceæ* are harmless, many beautiful (our gardens owe much to this family), some are valuable for food or other purposes,

and some few are poisonous. The Laburnum comes under this latter category. It is more or less acrid in all its parts, but specially so in its seeds, which should never be allowed to get into the possession of children endowed with that common juvenile propensity of putting things into their mouths. Our object, however, is not to write on "economic" or medical botany, but simply on structural points; let us then sum up by saying that our Laburnum flower is *complete*, inasmuch as it has all the organs which constitute a complete flower; that its sepals deviate from the simplest type in not being separate, and in being irregular in dimensions; that its petals manifest *irregular growth* to a much greater extent than the sepals, that its stamens are coherent, that its pistil is remarkable for being solitary, though all the other organs of the flower are in fives, hence probably four carpels are *suppressed*, at any rate we often see French Beans with two carpels, and there are foreign *Papilionaceæ* in which the flower is regularised by the production of five carpels. Hence, then, hypothetically at least, our Laburnum deviates from the regular standard (of which we shall have more to say by-and-by) in the fact that *suppression* has taken place in its pistil to such an extent that only one out of five carpels is present.

CHAPTER V.

The ROSE:—Prickles and thorns—pinnate leaves—imbrication of sepals—cup-shaped receptacle—double flowers—substitution of petals for stamens—carpels. ST. JOHN'S WORT:—Dotted leaves—definite inflorescence—oblique petals—branched stamens—placentas—capsule—uneven number of parts Summary—incomplete, complete and modified flowers; how modified and why—symmetry—succulent plants—spiral arrangement of leaves—alternation of parts. STONECROP.

IT requires a certain amount of moral courage to avoid the expression of one's feelings about a Rose. The temptation to introduce one of the many pretty sayings concerning it, made use of from the time of Herodotus to that of Reynolds Hole, is almost too strong to be resisted, and would be quite so, but for the "Book about Roses" of the latter author. We pass at once then to the "comparative anatomy" of the Rose (*Rosa*). It is perhaps fitting that we begin with the prickles. The beginner need hardly be assured that the primary object of these appendages is not that he may prick his fingers. They are rather to be regarded in the same light as the "crampons" which alpine travellers attach to their shoes to enable them to keep their footing more firmly; so these prickles assist the plant in maintaining itself in the hedgerow, and by holding on to its neighbours, enable the branches to do with a lesser outlay of woody materials than would be the case if they had to

support themselves by their own exertions. Again, the prickles form an effective defence. These explanations, we fear, will hardly hold good in the case of the garden Roses, but as these are but the civilised descendants from a once wild stock, they inherit some of the asperities of their ancestors. When we spoke of the prickles as "appendages," we did so advisedly, as we had in our mind the distinction which botanists draw between a prickle and a spine or thorn. In ordinary

Fig. 30.—Prickles of the Rose

language the two are confounded, but the more precise botanist recognises that one is a mere outgrowth from the bark, while the other is a stunted, sharply pointed branch, and as such may bear leaves, sometimes even flowers. No one ever saw the prickle (*aculeus*) of a Rose bear leaves. The nearest quickset hedge will show plenty of spines (*spinæ*) bearing leaves. A little pressure at the base will suffice to detach the prickle (fig. 30), because its attachments are superficial; but a spine proper cannot

be removed without breaking the woody cylinder of the branch, with which it is continuous. Let this serve as

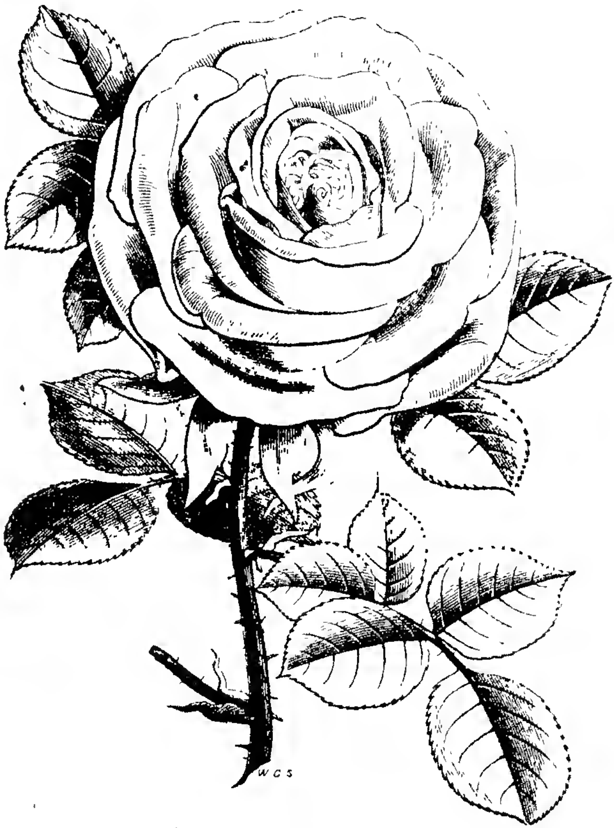


Fig 31.—Marechal Niel Rose.

another hint to the beginner, never to trust to superficial resemblances in natural history. Things may be very much alike and yet widely different in their nature.

The leaf of the Rose is a compound leaf, and of that particular variety of compound which is called *pinnate*, because the leaflets come off from each side of the main stalk, somewhat as the barbs of a feather (*pinna*) do from the quill (fig. 31). At the base of the leaf are the stipules,

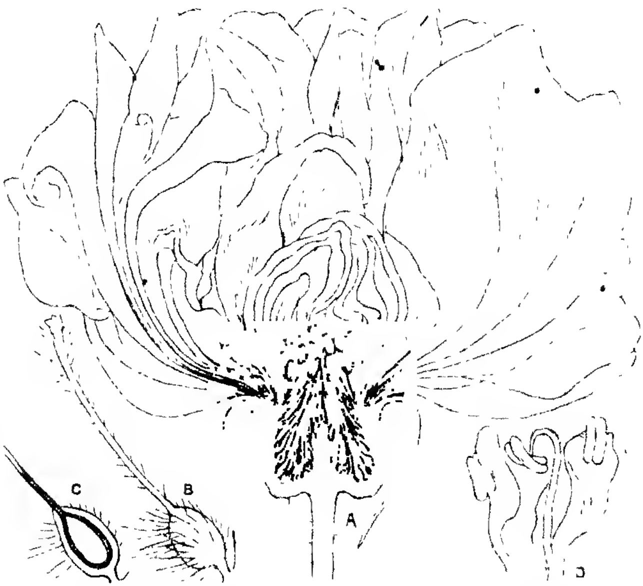


Fig 32.—A, Section lengthwise through the flower; B, Carpel separated, showing a stalked hairy ovary, surmounted by a long style, at the end of which is the stigma; C, Section through the flower; D, Intermediate organs, partly petal-like, partly stamen-like.

in this case *adnate* to, or rather only partially separate from, the leaf-stalk. The upper end of the flower-stalk or thalamus is dilated into a fleshy cup, which forms what boys call the "hip," and which varies much in form in different kinds of Roses. From the edge of this cup

spring five sepals, the leafy nature of which is very apparent in some Roses. In the bud the sepals overlap, *imbricate* as it is termed, and generally in such a manner that two are completely outside, two completely inside, and one sepal half in and half out. In other words the two outermost sepals are not overlapped at all, the two innermost are overlapped at each edge, while the intermediate sepal is overlapped on one side, and overlaps on the other. This arrangement can be seen in any young Rose-bud, but there are some varieties which show it better than others, because the two outer sepals are more leaf-like than the rest. Each one of the outer sepals has on either side a supplementary lobe, so that it resembles a compound leaf of three leaflets. The two inner sepals are quite destitute of these supplementary appendages, while the intermediate one has a lobe on its outer or exposed edge, and is destitute of any such growth on its inner or overlapped margin. As it is of a strictly scientific character, there can now be no harm in yielding to the temptation of quoting the following distich, which expresses the peculiarity just described with that terseness and precision which should characterise botanical descriptions:

> "Quinque sumus fratres, unus barbatus et alter,
> Imberbesque duo ; sum semiberbis ego ;"

which we may thus Anglicise :

> Bearded or beardless we are five;
> A pair with beards ; a pair with none;
> While I have only half a one.

The petals of the wild Rose are five in number,

roundish, and scarcely stalked ; the stamens are very numerous, and spring, together with the sepals and petals, from the edge of the receptacular cup. But in the cultivated Roses the flowers are *double.*

Doubling arises from various causes in different flowers. Sometimes the corolla, or the petals, are really increased in number without other change, as in the hose-in-hose Primrose, but the doubling which we meet with in the case of the Rose is of another character. Here the stamens are more or less completely replaced by petals. The little cellular tubercles, which constitute the first stage of stamen-life, instead of developing into perfect stamens, assume, as they grow, a petal-like form. Sometimes, as in the flower before us, the change is not perfect, and we meet with some bodies, part staminoid, part petaloid. Our flower, then, differs from the wild type of Rose in the substitution of petals for stamens, or, as it is sometimes, but less correctly, called, the metamorphosis of stamens to petals. This statement is incorrect, because the organs in question never were anything else than what they now are, and hence cannot have been metamorphosed.

The florists often horrify the botanists by the artificial and arbitrary character of their rules and "points." The florists may fairly retaliate, for does not a botanist call a double Rose a "monster?" and such, anatomically, it is. It so happens that monsters among animals are repulsive (except to an anatomist, to whom nothing that God has created is absolutely repulsive), but among plants they often constitute the most useful and most ornamental of all vegetable products.

The pistil of the Rose consists of a number of carpels springing from the bottom of the receptacle. Each carpel is shortly stalked (fig. 32, B), and consists of an ovary with a single ovule (seen in section at C in fig. 32), a long style, and a small terminal stigma. If the reader will now look back to the Apple described and figured at p. 32, he will see that, so far as the flower is concerned, there is a great resemblance between the Rose and the Apple; the principal differences between them are, that the leaves are simple in the Apple, compound in the Rose; while in the flower (setting on one side the "double" condition above alluded to the chief difference is, that the carpels become in time incorporated with the receptacle, as already explained; and in the Rose, although the receptacle swells and becomes succulent, the carpels remain free from it as in the Cherry (fig. 22, p. 36).

In fact, the Rose and the Apple are included by botanists in the same natural order, *Rosaceæ*, but in two different sub-divisions—the *Roseæ* and the *Pomaceæ*—characterised specially by the fruit, as already explained.

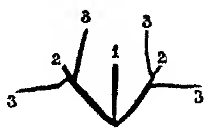
Our woods and hedges, no less than our gardens, will furnish illustrations of the genus *Hypericum*—St. John's Wort. There is a good deal of difference between the various species, but for our present object any kind will answer the purpose. Our illustration, in part borrowed from Decaisne and Maout's "Traité Général de Botanique," represents the commonest wild species, *Hypericum perforatum*, a plant very common throughout Britain, but most at home on a limestone soil.

The beginner will notice its wiry rigid stems, marked with two prominent ridges, and its sessile, exstipulate, opposite, and entire leaves. These terms have all been explained in previous pages, so that we need not repeat these matters, but at once advise the beginner to hold one of the leaves up so that the light may shine through it: he will then see why the plant is called *perforatum*.

Here, as in so many instances, the name conveys the appearance rather than the absolute truth. There are no perforations, though there appear to be. What, then, are the seeming holes? Let the leaves be crushed betwixt finger and thumb, and smelt, and a powerful aromatic perfume will be observed. This perfume depends on the presence of a highly scented volatile oil, which is stored up in certain cells or membranous bags in the leaf and indeed in other portions of the plant as well. These cells are larger than the others making up the tissue of the plant, and hence the light shines through them, and produces the appearance of the holes already alluded to—A, fig. 33. Leaves having this peculiarity are called *dotted* leaves. St. John's Worts are not the only plants that have these dotted leaves, and parenthetically it may be stated that some few Hypericums do not present this peculiarity. Oranges, Myrtles, Rues, have similar dots. The beginner will probably have vivid recollection of squeezing a piece of Orange-peel against the flame of a candle, and watching the "illuminations" that took place in consequence. In squeezing the Orange-peel some of these large cells, or *cysts*, as they are called, are broken, and the oily contents forcibly ejected into the flame,

there to catch fire, and thus produce the illuminations in question. Now, look at the inflorescence. Under the head of the Wallflower (p. 43), we explained the difference between *definite* and *indefinite* inflorescence, and instanced the Wallflower as a good illustration of the latter mode of producing flowers. The St. John's Wort affords an equally good example of the definite inflorescence. Follow up the main stalk, and observe that it ends in a flower. The growth is stopped or *defined* in that direction by a flower. That blossom, then, is the oldest of the series, it is in the centre of the inflorescence, and really, though perhaps not at first sight obviously, at the top.

The other flowers come off from below the first one, and they are placed at an angle with it. Suppose we call the central flower 1, then the relation it bears to the two next will be like this, 2, 1, 2—that is, the first formed flower, No. 1 is terminal to the main stalk, and is of course the oldest flower; 2—2 are terminal to the side stalks, formed after No. 1, and are both of the same age. Below flowers 2, 2, may perchance spring other flowers in the same way, 3, 3—3, 3, and in this manner we may get a series of forkings. Growth in any particular direc-



tion is soon arrested or defined, and if the growth is sub-

sequently resumed, it, proceeds at an angle to the preceding one, and not in the same direction. All

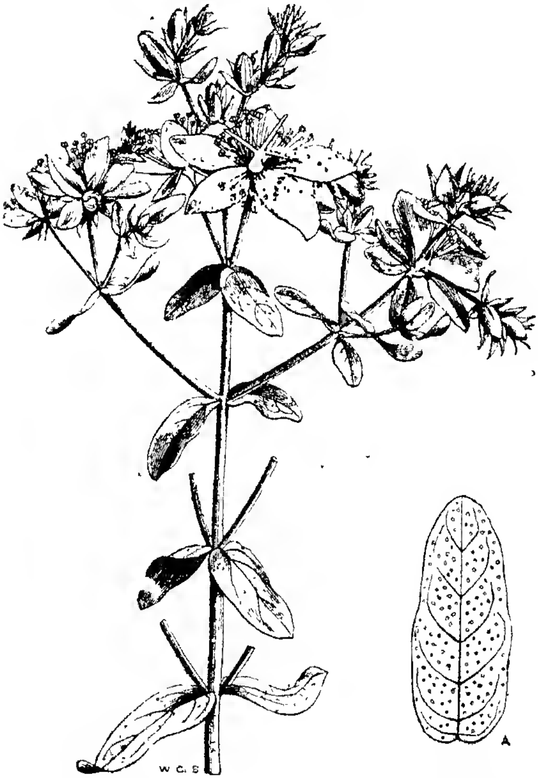


Fig. 33.—Spray of Hypericum perforatum.—A, "Dotted" leaf.

this takes a good many words to describe, but it may be seen in a moment, by looking at the inflorescence of an *Hypericum*, or of a Mouse-ear Chickweed (*Cerastium*),

and many other plants. The calyx of the *Hypericum* is made up of five free sepals, often studded with black dots, which are reservoirs for oily matter. Within the sepals are five yellow petals, generally a little lop-sided, or *oblique*—D, fig. 34, and then we come to the stamens, which are very numerous, and spring from below the ovary, being as it is called *hypogynous*, having no adhesion, either real or apparent, to the calyx or the

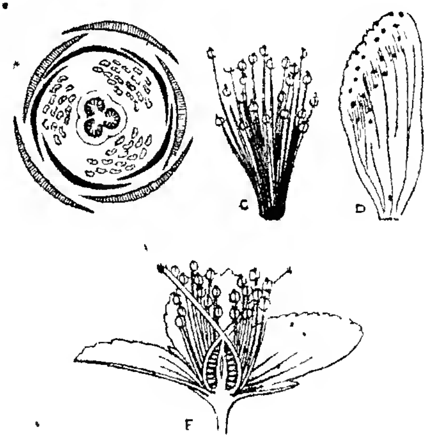


Fig. 34.—B, Diagram showing the arrangement and relative position of the parts of the flower; C A compound stamen; D, A petal oblique in form, and sprinkled with black dots, or glands E, Vertical section through a flower

sides of the ovary, but combined among themselves into three parcels, as may be seen best in young flowers or newly opened buds—B, C, fig. 34. Where stamens are thus united together, Linnæus used to call the several parcels *brotherhoods*—"*adèlphoi*," thus, in the Mallow, where they are all apparently in one parcel, the term monadelphous was used, meaning one brotherhood. In

the Hypericum the stamens are *triadelphous.* These terms, however, do not express the whole truth. The fact is, that in most of these cases the stamens correspond to lobed or compound leaves. Thus, each of the three parcels is a *compound* or branched stamen, so that instead of there being a great number of stamens, there are in the Hypericum only three, but each one divided into a number of subdivisions. Note, then, that the anther, which is usually considered to correspond to the blade of an ordinary leaf, does not always represent a simple or entire leaf, but sometimes, at any rate, only a portion of one.

Within the stamens is the ovary—E, fig. 34, made up of three carpels, as may be seen by cutting it across—B, fig. 34, when its three cavities may be seen, or by counting the three widely spreading styles, which equally indicate the ternary character of the pistil. The inner angles of the carpels bear numerous tiny ovules, and these ovule-bearing angles or placentas meet in the centre, or axis of the ovary, and produce what is termed an *axile placenta*—B, fig. 34. These carpels as they ripen become dry and woody, so that ultimately a *capsule* is formed, which splits into three pieces or valves, to allow the ripe seeds to fall out. The main structural features, then, of the St. John's Wort are the opposite, entire, exstipulate, and dotted leaves, the definite inflorescence, the lop-sided petals, the three compound stamens, the three carpels, and the capsular fruit. It is as well to notice the want of numerical correspondence between the calyx and corolla, which are both five-parted, and the stamens and pistil, which are both ternary. In

a truly regular flower all the parts are numerically similar, all in fives, or fours or threes, as the case may be ; but, as we have seen, the St. John's Wort constitutes an exception to this regularity of number, or rather some Hypericums do, for there are others in which the parts of the flowers are throughout in fives.

H. calycinum is not only one of the handsomest of hardy low growing shrubs, but it has the rare faculty of growing under the shade of trees where scarcely anything else will grow.

Some of the Hypericums have been used medicinally, on account of their resinous properties, and we have painful remembrance of an application that was made to a cut finger in our childhood, and which application consisted of the leaves of some St John's Wort steeped in some spirit. The application did no harm beyond the infliction of unnecessary pain, and it might have done good had a stimulant been really needed. We didn't know then—and if we had known, the knowledge would have been useless—that in most cases Nature heals a wound after her own fashion better than any one else can do it for her, even though the "vulnerary" consist of St. John's Wort.

We began our illustrations with *incomplete* flowers of the simplest construction, such as those of the Willow, Elm, Poplar, and Ash ; and from these we have proceeded to flowers of gradually increasing complexity, such as those of the Tulip, Hyacinth, Apple, Rose, &c., pointing attention in each case to the particular circumstances which produced the modification or complexity

of structure. We started thus with the simplest flowers, proceeded to those, such as the Poplar, in which a slight degree of modification was produced by the mere *addition* of parts, till we came to the Tulip, in which the flower is said to be *complete*, because it possesses all the constituent parts which a perfect flower should have, viz., a *perianth* of two rows, the outer one called *calyx*, the inner one called a *corolla* encircling the *stamens*, and these surrounding the central *pistil*. Our next step was to show how the parts of the flower were modified by what is termed *cohesion*, which is, as previously explained, more generally want of separation than absolute union of previously separate parts. *Adhesion*, or generally and more correctly speaking the want of separation of dissimilar organs, was exemplified in the case of the Hyacinth, p. 28, and Apple, p. 35; *irregular growth* by the stamens of the Wallflower, p. 46, or the petals of the Laburnum, p. 52; *suppression* of parts was exemplified in the case of the pistil of the Laburnum, p. 55, and the flowers of the Willow or Ash, pp. 6, 13, destitute as these latter are of perianth. *Multiplication* of parts was illustrated by the Rose, p. 61, and also the *substitution* of one part for another—for instance, of petals for stamens, as in so many double flowers, while the St. John's Wort yielded an illustration of *compound stamens*, p. 67. Incidentally in every case we have alluded to any salient features that the plant presented; but our special object has been to show the student how flowers are constructed, and to induce him to ascertain for himself what are the leading structural peculiarities in any particular flower he may happen to gather. Of course

when we use the words complete or incomplete, perfect or imperfect, we do so for convenience of arrangement only. So far as the plant itself is concerned, the simplest and least complex flower is as complete as one of greater complexity. That which it has pleased the Creator to make is assuredly complete for the purposes for which it is designed. A complete symmetrical flower, then, in a botanist's sense, is very often merely an artificial device constructed by the botanist for his own convenience as a standard of reference. Nevertheless, very many flowers do really conform almost precisely to the standard in their infantile condition, though, as they emerge from babyhood they become altered in some one or more of the ways we have above alluded to. Again, some few flowers do throughout their whole life maintain their original *symmetry*. As this word symmetry is used in different senses, it may be well, before proceeding further, to state that by symmetry we here understand the due proportion of the parts of a flower one to the other, thus we have a *symmetry of form and size* in which all the parts of the same kind, all the sepals of the calyx, all the petals of the corolla, and so on, are alike in shape and dimensions; a *symmetry of number*, according to which all the parts are in equal numbers, say five sepals, five petals, five stamens, or some multiple of those numbers, as five petals, ten (twice five) stamens, and so forth; a *symmetry* of arrangement, according to which all the several parts are separate one from the other, and disposed in their proper order. We have given several illustrations, showing how this symmetry of form, number and arrangement may be interfered with in various

cases, and it may now be well to put before the student a flower in which the symmetry of form and number is perfect, or nearly so, but which presents some deviation from the symmetry of arrangement. Such a flower is offered to us by the common Stonecrop, *Sedum acre* (fig. 38). The branches of this hardy little perennial are round or cylindrical, throwing out here and there fine threads or roots, and bearing a number of closely set alternate, sessile leaves. Funny things, too, these leaves are to look at—little fat conical masses of spongy tissue filled with watery sap. In truth the Stonecrops belong to what the French call *plantes grasses*, fat plants. Our term succulent, though longer, is more correct, for the tissues are filled with watery juice, not with fat. These leaves are covered with a thick rind, or skin, which does not allow the juice to evaporate very readily from the surface, and so we find these succulent plants can grow and thrive in hot dry situations, where plants with a more scanty provision of watery sap in their storerooms, or with a thinner rind, would perish from drought. Our particular Stonecrop is obliging enough to live in almost any situation, but, when truly wild, it is found on dry walls or rocks where little else will grow. The student must not imagine that all succulent plants are Sedums, or even near relatives of Sedum. Cactuses, Spurgeworts (fig. 35), and indeed a very large number of the family groups into which plants are divided, have some succulent representatives, which keep up the honour of the family name in quarters where the ordinary representatives could not do so—another hint, this, not to trust to external similarity only. Not to be too discursive, we

come back to the leaves of our Stonecrop. Notice on the branches which have no flowers how crowded they are, and then look at a branch which is bearing flowers,

Fig. 35.—Succulent Stem of Spurge (*Euphorbia*)

and see how the leaves are scattered at short distances one from the other. In fact, the stem between each leaf and its neighbour has perceptibly lengthened. Moreover, if the leaves be looked at attentively they will be seen to be arranged *spirally* round the stem.

The student should take any leaf near the base of a branch, and mark it in some way, then cast his eye carefully on the branch till he finds a leaf higher up, and

which stands immediately above the leaf first marked It will now be seen, by tracing the leaves one after the other, from the marked one below to that which is

Fig 36 —SEDUM ACRE (STONECROP).

immediately above it, that they are all arranged in a spiral coil. An easy method of seeing this spiral arrangement, is to fix a thread to the lower leaf, and carry it round the stem so as to touch the base of each leaf till that which is immediately over the one from which the start was made is reached. This spiral arrangement of parts is extremely common in plants, and when the eye is once accustomed to look for it, few things are more

readily discerned. A fir cone (p. 111) will show this at a glance. In all plants where the leaves or other parts are *alternate* this spiral arrangement necessarily occurs. If the observer be of a geometrical turn of mind, he will find the study of these spirals will open up to him a new and interesting object of research; but the subject is one too complex for the majority of beginners, and hence we shall not pursue it further. The inflorescence of the Stonecrop is definite, as in the St. John's Wort. Coming now to the flower, we find it in some respects a model of symmetry; the parts are symmetrical in number, form, and, with some exceptions, in position. We have already sufficiently explained the alternate, the spiral, and the opposite arrangement of leaves and other organs. This Stonecrop flower gives us an opportunity of saying some-

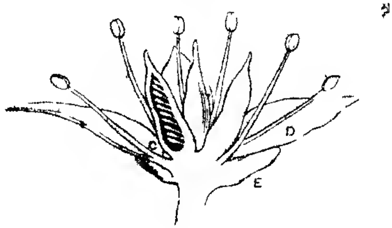


Fig 37.—STONECROP. SECTION THROUGH THE FLOWER

thing on the *whorled* or *verticillate* arrangement of parts.

The five sepals of the Sedum are in a ring or whorl, as also are the five petals, the ten stamens, and the five carpels. One sepal or one petal is not placed at a different height from the rest, but all come off at the same level. In the case of *opposite leaves* already referred to (p. 9), there are but two leaves in the whorl or ring

here in the Stonecrop there are five sepals in a whorl, and so on. In this plant, then, we have the leaves alternately and spirally arranged, while the parts of the

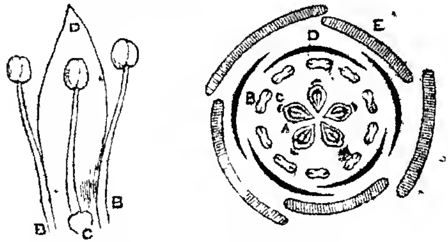


Fig. 38 Diagram showing the arrangement of the parts of the Flower.—A, Carpels; B, Stamens; C, Gland; D, Petal; E, Sepal.

flower are, in appearance, whorled. The symmetry of arrangement is thus different in the case of the leaves and of the parts of the flower; but in other cases, as for instance the Bedstraw (*Galium*), the whorled arrangement is found in the leaves and parts of the flower both. In the Stonecrop, then, we have a whorl of five separate sepals, a whorl of five separate petals, and so on, and these parts alternate with each other, so that one petal comes between two sepals. Five stamens alternate (and these are longer than the others) with the sepals, five other stamens alternate with the petals.

So far the alternation is perfect, but when we come to the carpels, we find them, as it were, out of place; they should alternate with the petals, but they do not. In this particular then, the *law of alternation*, as it is called, is not followed.

The diagrams at fig. 38 will exemplify what we have been saying, but we may, perhaps, make this matter

even simpler by calling attention to the two succeeding plans, in one of which (fig. 39) the parts of the flower alternate in pairs, two sepals, two petals, two stamens, and two carpels; while in the other (fig. 40) they are

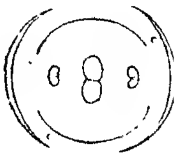


Fig 39.—Diagram of two parted flower

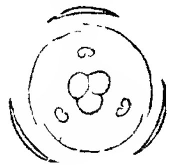


Fig. 40.—Three-parted flower

arranged in groups or whorls of three. We may also illustrate the relative position of the parts of the flower by the following scheme representing the arrangement in a regular flower, whose parts are in fives, and wherein S represents the sepals, P the petals, st the stamens, and C the carpels :—

S		S		S		S		S	
	P		P		P		P		P
st		st		st		st		st	
	st		st		st		st		st
C		C		C		C		C	

Now in the Stonecrop the arrangement is :—

S		S		S		S		S	
	P		P		P		P		P
st		st		st		st		st	
	st		st		st		st		st
	C		C		C		C		C

The explanation of this peculiar position of the carpels

in relation to the stamens, as also of certain little glands (C, fig. 38) which also deviate from the proper alternate position, is a problem for the advanced botanist to solve rather than the beginner, and hence we confine ourselves now to the mere mention of the fact.

CHAPTER VI.

Composite flowers. DAISY and DANDELION :—Flower heads—involucre, —general receptacle—ray florets—disc florets—pappus—ligulate and tubular florets—Orchids. LÆLIA :—Geographical distribution of orchids—reasons for their dispersion—epiphytes—parasites—pseudo-bulbs—structure of flower—lip—column—gynandrous condition —pollen masses—rostellum—mechanism of fertilisation—agency of insects. WHEAT :—Stems of grasses—nodes—internodes—ligules—inflorescence—spikelet, glumes, &c.

IT has often been our lot to look through local herbaria and collections made by juvenile botanists, and to note the comparative rarity with which such common plants as the Daisy and Dandelion are collected and preserved. This arises, probably, from the frequency of their occurrence. What can be got at any time is very liable not to be procured at all. Another phenomenon of quite an opposite character, and which has very often struck us, is this, that the would-be botanist has a tendency to try his hand, at first starting, on Daisies and Dandelions, under the impression, perhaps, that they must be easy, because they are common. It is quite necessary to dissipate this notion, and to recommend the student to begin his dissections with flowers of simpler character and larger size, such as those mentioned in the earlier pages of this volume. In truth, the so-called flower of these plants is really a mass of tiny

flowers. A Sunflower, a Dahlia, an Aster, a Chrysanthemum, all of which are near allies of our humbler Daisies and Dandelions, in like manner do not bear single blossoms, but a large number of minute flowers—florets as they are called—grouped into heads; hence

Fig. 41.—Daisy.

the term composite flowers; hence also the name *Compositæ* applied to the whole group, a group the most extensive, in point of numbers, of any in the whole series of flowering plants, and one in general readily recognised by the flowers being in "heads" as above described, and, invariably, by the anthers being joined together or

coherent by their edges. The combination of these two circumstances is quite enough to enable us to detect a Composite. The mere fact of the flowers being in heads is in itself not sufficient, inasmuch as many other plants, besides Composites, have their flowers in heads. Disregarding for the present other characteristics of the Composites as a whole, let us indicate some of the structural peculiarities of the two plants before us. In the Daisy, (*Bellis*) as in the Dandelion (*Leontodon*), the true stem is excessively short. The consequence of this is that the leaves are closely packed, and spring, as it were, from the very top of the root, and lie flat on, or at no great distance from, the ground. The main distinction between the stem and the root consists in the power that the stem has of bearing leaves in some shape or another. A true root has, as a general rule, no such power, and so when, a few lines previously, we described the leaves as springing from the top of the root, we committed a technical error. The so-called top of the root, or crown of the root as a gardener would call it, is really in this case a short subterranean stem, short because the internodes are not developed. In the House-leek, or in a bulb, the leaves are closely packed from the same cause,—the spaces between them are not developed. So in an ordinary flower, the sepals, petals, and stamens are all in close approximation, because the internodes are not formed. Thrust forth from the axils of the leaves in the Daisy and Dandelion rise the flower-stalks, straight, undivided, usually leafless branches, bearing at the summit the head of flowers surrounded by a ring or rings of small closely packed green leaves or bracts. This ring of bracts has very

much of the appearance of a calyx, but a calyx belongs to a single flower; this ring of bracts encloses a large number of flowers, hence the necessity for the distinguishing term of *involucre*, which is applied to a ring of bracts encircling a number of flowers.

In the case of the Dandelion the involucre, as shown at E, fig. 45, p. 86, consists of two or three rings of bracts, of which the outer are bent downwards, while the inner are erect. Pull off all the flowers within the involucre, or cut the flower through the centre from below

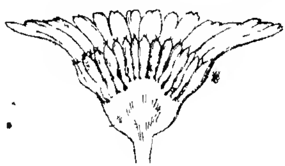


Fig. 42.—Section through Daisy Flower, showing Receptacle.

upwards, and the end of the flower-stalk will be seen expanded into a flat cushion in the Dandelion (fig. 45, P),

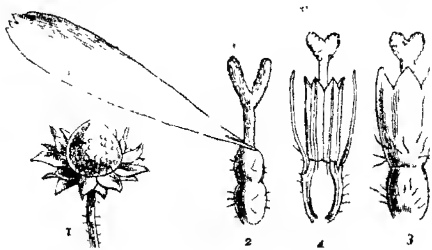


Fig. 43. Separated Florets of Daisy.—1, Receptacle and involucre; 2, Ray-floret; 3, Floret of disc; 4, Section of floret of disc, showing stamens.

or into a sugar-loaf-shaped mass in the Daisy (1, fig. 43). This expanded portion is the *general recep-*

tacle, from which all the florets spring. It bears the same relation to all the florets of the head that the *thalamus* does to each individual flower. Children have a

Fig 44.—Dandelion.

very ready way of demonstrating the general receptacle of the Dandelion, when they blow off the feathery

seed-vessels to see, as they say, what o'clock it is (O, P, fig. 45.)

Now we come to an important difference between the Daisy and the Dandelion. The florets of the former (fig. 43) are of two different shapes and of two different colours—"daisies pied," as Shakspere, and Milton after him, called them. At the circumference we have a ring of white florets, often "crimson-tipped," as Burns describes them, and in the centre a dense mass of yellow tubes. The white florets (fig. 43, 2) are those of the *ray*, the central yellow ones are the florets of the *disc* (fig. 43, 3). In the case of the Dandelion (fig. 44) (which, beautiful as it is, does not seem to have attracted the attention of the poets), the florets are all of one shape and colour, and hence there is in that plant no distinction into florets of the disc and of the ray respectively.

Picking off a ray-floret of a Daisy, the beginner will look in vain for a calyx. In truth, the calyx, distinct at a very early age, becomes fused with the ovary long before maturity, so that in the adult stage no trace of it, except in connection with the ovary, is visible. The calyx, though similarly adherent to the ovary in all Composites, generally presents more traces of its whereabouts than is the case in the Daisy, as will shortly be pointed out. The corolla is much more conspicuous; the "wee modest crimson-tipped" strap is the corolla, in fact, but a corolla of peculiar shape.

Let us describe the floret as it appears, and then attempt to explain the peculiarity. Each of the florets of the Daisy (2, fig. 43) has below a short tubular portion; suddenly there comes an alteration, the tubular

form is exchanged for that of a flattened strap turned to one side, and at the tip of the strap are usually to be seen two or more shallow notches. These notches are all that are left to indicate five petals. In point of fact that now apparently simple strap is a compound of five petals united together, turned to one side, except at the very base, where they are in their ring-like order, and form the short tube. This is hard to see certainly, and may be hard to be believed, nevertheless the advanced pupil will have no difficulty in verifying the statement by a comparison with other Composites, in which the five petals are more clearly distinguishable. Even the Dandelion (fig. 45, A) may help to make this matter more apparent. The ray florets of the Daisy, then, are made up of five petals, absolutely free only at the extreme tips, imperfectly separate in the middle, where they form a flat strap, perfectly inseparate or connate below, where they form a tube. At the base of the strap-shaped floret thus constituted, is the ovary, of a single cavity with a single ovule in it, and surmounted by a style, apparently single, but really of two congenitally blended, except at the extremity, where the two stigmatic ends reveal the constitution of the style. There are no stamens in these florets.

The florets of the disc (3, 4, fig. 43) are of a different nature. The calyx is the same as in the former case, but the corolla is of a strictly regular tubular form, made up, as may easily be seen, of five petals, free at the tips, inseparate below. Slit up the tube with a needle or knife point, and the five stamens will be seen inseparate from the corolla below, the filaments are free, but

the anthers cohere by their edges into a sheath or tube, surrounding the style, so that with a little care one may easily extract the style without disturbing the sheath formed by the stamens. This cohesion of the anthers is the characteristic mark of Composites, and it is worth noting that this is a case of true cohesion as contrasted with inseparation; for the anthers are originally separate, but become coherent.

The style is essentially of the same conformation as in the ray-florets.

Turning now to the Dandelion (figs. 44, 45), we find all the florets are strap-shaped, and that all have both stamens and styles. Moreover, the calyx is more apparent than in the case of the Daisy, inasmuch as, instead of being wholly blended with the ovary, a portion is free and is easily recognisable, from its light, feathery-looking appearance (fig. 45, B). A feathery calyx of this description is called a *pappus*, and a very large number of Composites have this pappus calyx, which is only too familiar to gardeners in the form of Thistle-down or Groundsel. It generally increases in size as the seed vessel ripens, perhaps in correspondence with the increased weight of the seed, which it serves to transport on the wings of the wind. The other points in the construction of the Dandelion have either been already mentioned, or are too similar to those of the Daisy to demand further notice in this place.

The two forms of the corolla are readily enough observable in many of our garden flowers—the Sunflower or Marigold, for instance, with their ray-florets and their florets of the disc; the Dahlia and Chrysanthemum, in

which the florets of the disc have, by the gardener's art, been brought to resemble the florets of the ray. In

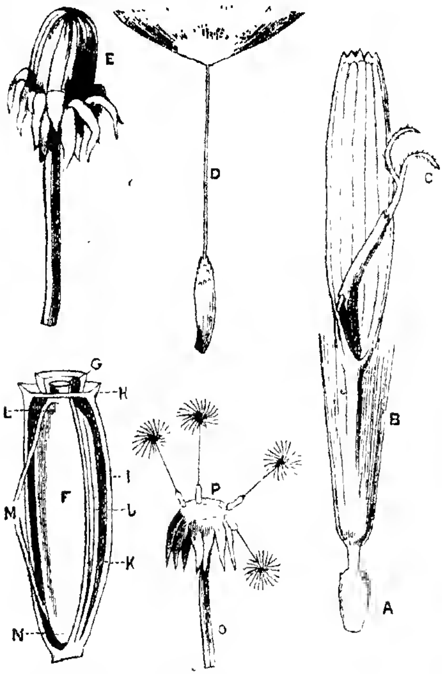


Fig. 45 Structural Details of the Dandelion.—A, Ovary, B, Pappus calyx, above which is the strap-shaped corolla, and the stigmas, C, protruding from the anther-tube, D, Ovary, with tubular calyx, ending above in pappus, E, Involucre, outer bracts reflexed, inner ones erect, F, Ovary, G, Disc, H, Calyx; I, Lower part of calyx adherent to the ovary, J, Ovule, K, Raphe, or cord suspending the seed, L, Base of the seed, M, Vascular bundle, N, Point of seed, O, Peduncle; P, General receptacle, with four fruits still attached to it.

Nature we have some Composites with strap-shaped florets only, as the Dandelion, Lettuce, Chicory, &c.; the plants of this group have usually a milky juice. There are others which in the wild state have tubular

florets only, like the Thistles; while a third group, including the Daisy, the wild Chrysanthemum, the Coreopsis, and a host of garden flowers, have both forms associated in the same head.

Everybody likes Orchids. They command the admiration or attract the attention of all classes of flower-lovers. People dote upon Roses, and rightly so; their beauty and their perfume quite justify the popular allegiance. Admitting all this, it may yet be said, in a general sense, that their attractiveness is confined to the two qualities just mentioned; but in the case of Orchids there are so many features of interest that each individual, we may almost say, may admire them for a different reason. The group *Orchidaceæ* seems to include within its limits all the attributes which make flowers attractive: beauty of form and colour, quaintness of shape, now large, now small; now mimicking in form a butterfly, in another species resembling a bird (fig. 46), in a third a reptile, in another presenting the aspect of some grotesque mask; flowering in winter, flowering in summer; growing in the ground, living on trees, thriving high up on the mountain side, flourishing in the moist hot woods of Java, abundant on our English downs, to be found alike in the old hemisphere and in the new world, in the far north and in the extreme south. In the whole globe there is scarcely a region where a flower will grow at all, but an Orchid of some kind may be found. We do not mean to assert that they are to be found in equal abundance in all districts—far from it, we merely state that one of the circumstances

which lends interest to the Orchid family, is its cosmopolitanism. To advanced botanists of a speculative turn of mind, it is of course a matter of great interest to account for this fact, and to ascertain whether the Orchids of these varied forms in which we see them, were originally formed as and where we now see them, or whether they were formed differently in the begin-

Fig 46.—Snipe Orchis

ning and in a few places only, whence in course of ages they have spread over the globe, becoming changed by force of circumstances, till that wonderful variety we now see has been attained. If this has been so, how and when did they migrate from place to place? what mode of conveyance had they? If their appearance has been changed, how and why has the change been brought about? To many, such enquiries as these have a charm and a fascination which no mere florist, no mere

collector or potterer over dried sticks in an herbarium can realise. The beginner, however, for whom these notes are penned, will be apt to say, "Such knowledge is too wonderful for me, I cannot attain unto it." But in all humility be it spoken, he *can* attain to it to a certain extent, and it is that very circumstance that should stimulate him to study God's works as fully as the means at his disposal will allow. Let us not be misunderstood. No amount of speculation, apart from the search for and accumulation of facts, will avail him aught—it will be so much waste labour and loss of time. His speculative faculty must be turned to account, not in framing mental figments on a baseless foundation, but in divining the meaning and importance of the facts before him; this will be as fertile in good results as the other will be sterile. New facts and new aspects of old facts will continually arise before him, and if he never attain to the full fruition of knowledge, which is not for finite beings to hope for here, at least he will always be progressing and extending his knowledge of the marvels of Creation. We have alluded to these matters in this place, not with any view of following them up, for that would demand far too much space, but simply to indicate to the beginner what fields of knowledge lie before him, if he will but choose to enter them, and to urge him to take no contracted views of botanical science—to look beyond the collecting box, the magnifying glass, and the herbarium, and the minute distinctions of the text-books and Floras, and to consider all these as means to an end—invaluable as aids, but not to be confounded with the object to be attained. We do

not know any group of plants better calculated to serve as illustrations of the facts and phenomena of plant-life than Orchids. Vegetable conformation and minute structure, physiology, or the office of all the several parts of the plants, singly or in unison, the phenomena of geographical distribution—each and all of these involving questions of direct practical importance to the plant grower, the food producer, the merchant—are to be studied under favourable conditions in the Orchids. Here we must limit ourselves strictly to the consideration of sundry salient features in the construction of these plants. Our illustration (fig. 47) shows the flower of one of the many Orchids which, growing *on* trees, but not *in* them, are called *epiphytes.* Unlike the Mistleto, unlike the Orobanches, and a host of moulds and fungus-blights, which penetrate the tissues of the plant on which they grow, and feed on its juices, and which are therefore fitly called parasites, the Orchids simply use the bough on which they grow as a vantage ground for obtaining that light and air and water on which they feed. Once conveyed into the laboratory, changes, only half understood as yet, occur to fit the absorbed matters for use in the plant, and to provide a store for future requirements. This latter office is fulfilled by the peculiar swellings of the stem which most epiphytal Orchids have, and which are known as *pseudo-bulbs.* Terrestrial Orchids, like our English Orchids, have similar reservoirs in their roots, which form tubers of various kinds. On the leaves we need not say anything, but pass on at once to the flower, in which, for our present purpose, the interest centres.

Any Orchid flower likely to be met with in our stoves or in our fields will serve our purpose, with the exception of Cypripedium, which presents sundry special modifications. Let the pupil refer to what we have said as to the Tulip or Hyacinth (Chap. II.,) and consider that he has before him, in the case of an Orchid, a flower of essentially similar character, but modified to an extraordinary degree. It so happens that this Lælia (fig. 47) is not so much modified as many Orchids are—all the better for our purpose, as it will be easier for the pupil, and show him that there are many intermediate stages between an Orchid, which is nearly as regular as a Crocus or an Amaryllis, and those wonderfully complex-looking, gnarled Oncidiums or Stanhopeas. In our Lælia, then, we have an inferior ovary (fig. 47, P) more correctly an ovary which is adherent to the base of the perianth. Suppose the tube of the flower of the Hyacinth (p. 23) to be adherent to the ovary, and you would have a condition precisely like that of the ovary of an Orchid. The perianth is like that of the Tulip, in two rows (fig. 47, A A A, B B C,) of three pieces each, but one of the inner pieces is unlike the rest in form and colour; this is what is called the lip. In our Lælia the lip is tolerably regular, but everyone who knows an Orchid at all, knows how wonderfully varied are the forms, the knobs, the ridges, the tails, the crests, the spurs and other appendages which the lip presents in different cases. Some say there is an occult structural significance in all these; there may be, at any rate there is physiological importance, and there is a practical end, which is this: in the first place to attract insects, and in

the next to make those insects travel in a particular course, and in so doing serve a particular purpose to be hereafter explained. In those Orchids which are provided with a long spur it is the lip which forms it, and in the spur is honey, and the ridges and crests of the lip are but as finger-posts and tramways to guide the insect in the way he should go to get at the honey. Within the perianth stands the "column" (fig. 47, D.) What is this column? By this time the pupil would of course at once guess that it had something to do with the stamens or the pistil, but he would hardly be prepared for the announcement that it had to do with both. In truth, however, the column is caused by a blending of the stamens with the styles—one perfect stamen, two imperfect ones, or perhaps even five, and three styles, all blended into one mass, producing what in botany is called a gynandrous state. Incredible! says the sceptic. Not so, says the botanist, who sees in the wings with which the column is often provided, in the internal structure, in the infantile condition, and specially in the comparison with other Orchids, proof positive of the assertion just made, and he makes proof doubly sure by producing flowers in various intermediate conditions, and by demonstrating that in all Orchids in their

Fig. 47. LÆLIA AUTUMNALIS.—A A A, Sepals, B B, Side petals; C, Lip or Labellum; D, Column, E, Anther *in situ*; F, Side view of upper part of column showing stigma and projecting "rostellum," above which is the anther G partially detached as by an insect, and showing the pollen masses; H, Shows the position of the pollen masses in the anthers; J, Inner surface of anther, pollen masses *in situ*; K, Inner surface of anther after the removal of the pollen masses, L, Pollen masses with their discs; M, Top of the column after the removal of the anther, N, Stigma; at O all the parts of the flower are cut away, except half the lip, the column, D, and the ovary, P; Q, Cut across the ovary Between O and Q is shown a cut lengthwise through the centre of the column; N, shows the stigmatic cavity, and above it, separated by the rostellum, is the anther.

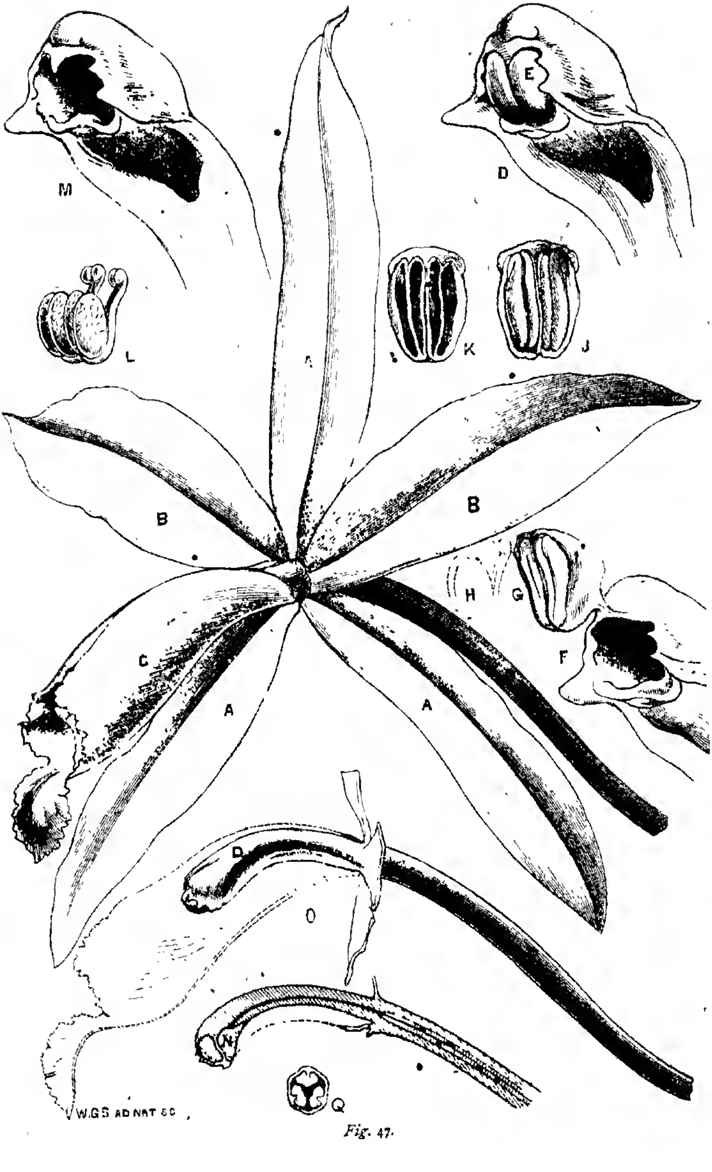


Fig. 47.

springs of wonderfully diverse patterns and modes of action. Even the threads of the pollen-masses themselves are often endowed with a power of motion or contraction; and the springs are formed from various processes of the column; and the aim of all this is to secure the removal of the pollen at the right time, its transfer to another flower, and its proper direction or position when it has been so transferred, for it must be remembered that when coiled up in the anther, it is not in the most advantageous position for use, and hence, when liberated, it moves by its own inherent power of motion into the right direction. All this is done so perfectly that one might imagine it directed by reason. Nay, is not the plant as reasonable as the insect which is unconsciously made the go-between? We can only indicate in a very general way the processes which take place in an Orchid flower; but we would recommend the pupil to peruse Mr. Darwin's "Fertilisation of Orchids," where he will find many details of the structure and office of the several parts of the flower, in most of the genera of this family in cultivation in this country. If, after the perusal of that book, he does not find he has a somewhat more enlarged view of plant life than he had before, he had better pursue some other avocation in the future.

Wheat (*Triticum*).—Those who are inclined to twit botanists with the *cui bono* argument—and the race is not quite extinct—may be met by the fact that neither they nor anyone else could exist without plants. Plant life is essential to animal life, animal life is the complement to

that of plants. Hence some knowledge of plant life may be deemed essential. We do not intend at present to enter at any length upon physiological questions, but it may surely be said that an acquaintance with the plants producing the *staff of life* comes under the head of useful knowledge. Nevertheless, we think we do not err when we state that even among those who have a smattering of botanical lore less is known of the grasses than of almost any other group of plants. This happens no doubt from the difficulty of dissecting their flowers, and from the fact that their construction is, at first sight at any rate, so different from that of other plants. The difficulty of dissecting the flowers of grasses, arises from their general small size, their dense approximation, and from the dryness and rigidity of their flowers, which renders the dismemberment of them a matter requiring some patience and dexterity. For these reasons we have deferred the consideration of their structure till the beginner, presuming that he has followed us so far, may be supposed to have attained something of the requisite dexterity from practice on flowers of easier construction.

What we are now about to say concerning the Wheat is applicable, *mutatis mutandis*, to other grasses. Before passing on to the flower, however, let us glance at the other parts of the plant.

The fibrous roots demand but little explanation at our hand, but the stem of the grasses—the straw, being in many respects different from that of other plants, requires some notice. In the first place it is herbaceous, that is, not woody; then it may be noted that its form is cylindrical, and that it is hollow in the interior. The

stem, in fact, is tubular, but the tube is interrupted here and there by partitions which will be found at the points whence the leaves proceed—points, moreover, marked in the case of the grasses by a little thickening called technically a *node* or knot. It is useful to know that the spot whence a leaf proceeds is always called in botany a node, even though a swelling be not always present in that situation. The space between two nodes is, as before explained, called the *internode*. When the leaves are crowded together the internodes are necessarily very short; but here in the Wheat the leaves are separated by rather long internodes. The tubular form of the stem, or straw of Wheat, furnishes considerable strength, at the same time that economy of material is secured. Strength is also supplied by the hard flinty substance which is contained in the skin or rind of all the grasses, and which exists in such quantities that the stem may, with care, be burnt, or destroyed by strong acids, and yet the skeleton of the plant will remain, showing the form of the stem. To do this, however, requires some skill, and the beginner will probably realise the fact almost as well when we tell him that the rigidity of grasses as well as the glossy appearance of the straw is due to this silex, or flinty material. All grasses, with the exception of the Sugar-cane, and one or two others, have tubular jointed stems. The leaves, too, of grasses are characteristic. If the leaf of the Wheat plant be carefully stripped off, it will be seen to consist of a sheathing portion wrapping round the stem, and a flat, ribbon-like portion, the *blade*, quite detached from the stem, and having no one rib larger

Fig. 48.

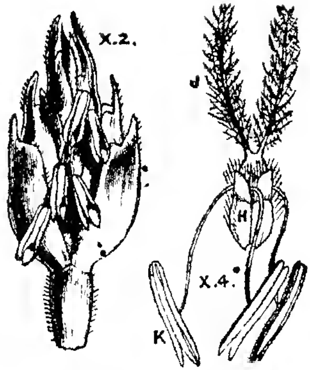


Fig. 49.

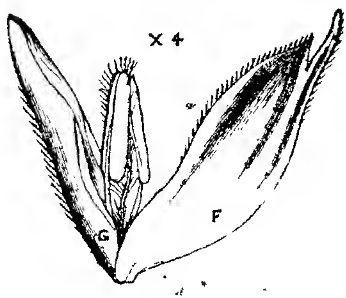


Fig. 50.

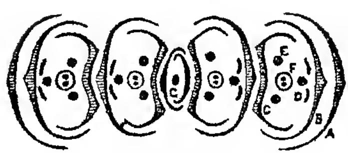


Fig 51.

Fig. 48. Ear or spike of Wheat, bearing numerous spikelets (seen from the side).
Fig. 49. Left-hand figure: Spikelet separated, the two lowermost scales are the glumes.
Right-hand figure: The flower divested of the glumes and pales (see text).
Fig 50. Flower of Wheat invested by the flowering glume and pale (see text).
Fig. 51. Diagram showing the arrangement of the parts in a spikelet of Wheat (see text).

than the rest—no midrib larger than the rest, but a great number, all of about the same size, and running parallel from the base to the point of the leaf. The blade of a grass-leaf is always entire, not notched or divided in any way. Just at the junction between the sheath and the blade of the leaf may be seen in all grasses a small but characteristic membranous outgrowth, technically called a *ligule*, and which is peculiar to grasses.

A botanist seeing a fragment of a leaf with this little membranous process emerging from it, would at once pronounce the fragment to have belonged to some grass. Sedges, which in so many cases resemble grasses, and are constantly confounded with them, may be recognised at once by their triangular stems, and their leaves destitute of *ligules*.

Coming now to the flowers of the Wheat, we find them closely packed on either side of the top of the stem, and if they be pulled off from the ear, the inflorescence, that is, the stem, may be seen to have lost its cylindrical form, and to have become flattened and bent zig-zag fashion. Here is a provision for securing economy of space; the flattening allows more room for the flowers, and the zig-zag bends allow the flowers above to fit into those below. It may be well to state that the inflorescence of the Wheat is called a *spike*, and its flattened portion is called the *rachis* (fig. 48).

It might at first be supposed that what we have just called the flowers, and which we recommended to be stripped off to show the flattened rachis, were single flowers; this, however, is not the case: they are groups

of flowers, and to each little packet or group. the term *spikelet* is applied (fig. 49). These spikelets are densely packed in the case of Wheat, but in the Oat they are more loosely arranged, and form a panicle. We have then to see what these spikelets are composed of. The beginner must not be disheartened if at first he can see nothing but a confused mass of scales; let him be assured that there is no real confusion, and that a little patience will enable him to see that each spikelet consists, first, of two scales, one to the right hand, the other to the left. By seizing with the fingers the top of the spikelet, these two lower scales, or *glumes*, as they are called, may be left *in situ*, and may then be seen to be attached to the main stem or rachis, and to be of the nature of bracts, enclosing three or more small flowers, supposed to be pulled off by the observer.

Each of these tiny flowers (the numbers vary in different grasses, and even in different varieties of Wheat) has an exceedingly short stalk or peduncle, so short, indeed, that the beginner may be pardoned if he fail to see it. Proceeding with his dissection of a flower, he will next come to a scale like those already referred to in form and appearance, but clearly not attached to the main stem or rachis, inasmuch as it is pulled off with the flower; it must, then, belong to the exceedingly short peduncle, already referred to as supporting the flower, and is indeed the best evidence we have of the existence of the stalk, as that is too short to be readily seen. That the scale does not belong to the flower is seen by the fact that it completely encircles the flower below, which it would not do if it formed part of the

flower proper. This scale is called the *flowering glume*, and is of the nature of a bract; it is often provided with a long thread at the top, called an *awn* (fig. 50, F). The "beard" of some varieties of Wheat or of Barley or [illegible] is constituted by the awn springing from the [illegible] glume. If this be now carefully removed with [illegible] or point of the penknife, yet another scale may be seen on the other side of the flower to the one [illegible] mentioned, and a little higher up (fig. 50, G); this may be readily recognised, because it is marked by two ribs, whence it is supposed that it may really be made up of two scales united together. But this is still a moot point, as is also the question whether we are to consider this two-ribbed scale or *palea* as a bract or a part of the flower proper.

The beginner will do well to fix his attention on the form and position of this pale, and to leave the consideration of its structural significance to more experienced botanists. If the pale be now removed, three (in some grasses, as Rice, six or even more) very delicate stamens will be seen (fig. 49, K). As the student should proceed in all things systematically, before he examines these stamens let him carefully search for two minute white or transparent membranous scales at the base of the stamens (fig. 49, H); he will very probably fail to see them at first, but a little patience will enable him to disentangle them. These two scales or lodicles are fringed at the top in the case of the Wheat, and are the only representatives of the sepals or perianth of more perfect flowers (unless, indeed, which is possible, the pale really constitute the outer investment of the

flower) ; the filaments of the stamens are entirely separate, both from each other and from other parts of the flower, and each bears a long narrow anther, so delicately poised that it moves with a touch, hence the term *versatile* as applied to the anthers of grasses. Each anther (fig. 49, K) is divided into two lobes, which are separate at each end, thus forming a notch at both extremities of the anther. Next, we come to the pistil (fig. 49, J), here composed of a single oblong carpel, downy at the top, and provided with two rather long feathery stigmas. In the interior of the carpel is the seed or grain, which as it ripens becomes confluent with the carpel, and ultimately inseparate from it. In the young state the carpel may be distinguished by its white or colourless appearance, while the outer portion of the seed is green. The interior seed consists of a mass of floury substance, the albumen (flour), and at one end, from a little cavity of it, may be picked out a little button-like mass, which is the embryo plant, and on whose structure we shall have more to say at another time. (*See* Chap. VIII.)

Complicated as the structure of the inflorescence of grasses seems, it is not so much so in reality—thus, to sum up :—There is a main stem (the rachis) which bears at each notch two glumes or bracts, arranged alternately. Within these latter the rachis divides, and on each secondary branch or peduncle so formed are again two bracts, arranged alternately one over the other, *i. e.*, the flowering glume and the pale, then comes the flower proper with its two lodicles. In some grasses three are present, and then we have a whorl of three lodicles,

like a calyx of three sepals. The stamens are regular enough. The pistil is peculiar in having but one carpel. It may be assumed that two are suppressed, as very rarely, by accident, the other two are developed. The fruit is remarkable for the intimate blending that occurs between it and the contained seed.

The diagram fig. 51 represents a plan of the arrangement of the parts in a spikelet of Wheat, supposed to be cut across to show its four perfect and one imperfect flower in the centre; A represents one of the two glumes common to all the flowers; B is the flowering glume, of which there is one to each flower; C, the two-ribbed pale, with one of which each flower is also provided; D shows the lodicle, of which each flower possesses two, rarely three; E indicates a stamen, of which there are generally three, and F is the pistil.

To make our account of the Wheat complete, we ought to add that the topmost flower (or in some cases flowers) of the spikelets are rudimentary merely. In other grasses, *e. g.*, Barley, two of the lower flowers are rudimentary, the central one alone perfect. The man who can make two blades of grass grow where only one did before is a benefactor to his kind, so also is he who can induce the Wheat or the Barley to perfect their usually barren flowers and make them productive, and to a certain extent this has been done. As we started with an allusion to the *cui bono* cry, let us end by asking how this could be done if the would-be benefactor knew nothing of the structure of the flower of grasses?

CHAPTER VII.

FRUIT OR SEED-VESSEL—The matured pistil, with or without the addition of other parts—Changes during ripening—Dry splitting fruits—Indehiscent fruits—Succulent fruits—Nuts—Pods—Stone-fruit—Berries—Cones—Seeds—Fertilisation of the flower—Action of the pollen—Hybridisation—Sports—Selection—Forms of Seeds.

TO complete our survey of the general principles of the construction of flowering plants, it is necessary to say a few words relating to the construction of Fruits. To start with, we must remind the reader that the word "fruit," as used by botanists, has a different signification from that which it has in ordinary language. The fruit to a botanist implies the case containing the seeds, whether that case be edible or not. It might, therefore, fairly be inferred, that the structure of the fruit was the same as that of the pistil, or of its component carpels, but this would be only partially true, for the pistil, as it ripens into the fruit, often becomes so altered, that its original constitution can with difficulty be recognised. Moreover, during the ripening process, it very often happens that the pistil becomes embedded in, or incorporated with, some other part of the flower. As a consequence of these and other changes, the variations in the different forms of fruit or seed-vessel are very numerous, and in books the names applied to these

forms are equally abundant. It is not necessary for the beginner to trouble himself about many of these names,

Fig. 52.—SEED-VESSEL of Poplar

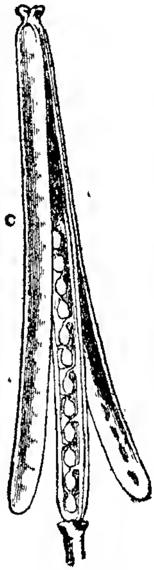


Fig 53.—Silique of Wall-flower. c valves.

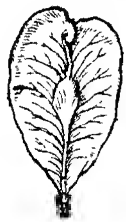


Fig. 54.—Samara of Elm.

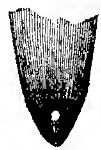


Fig 55.—Seed of Willow.

particularly as the sense in which they are employed varies in the practice of different writers. The plants that have already been alluded to in the foregoing pages afford illustrations of several kinds of fruits; it will therefore be as well to take them as examples.

In the Laburnum, for instance, the fruit does not differ materially from the ovary. It is larger, and it is no longer herbaceous but dry, and when ripe it splits into two pieces, or valves, to liberate the seeds. It is there-

fore a *dry* fruit and a *dehiscent* fruit, *i.e.*, it splits when ripe (see fig. 29, p. 54). Of a similar nature is the fruit of the Willow or Poplar (see fig. 52), but with this difference,—the fruit of the Laburnum is simple, that is, it is produced from a solitary carpel, but in the two trees just mentioned, two carpels make up the ovary, and these two carpels are disjoined in the ripe fruit. It is not easy at

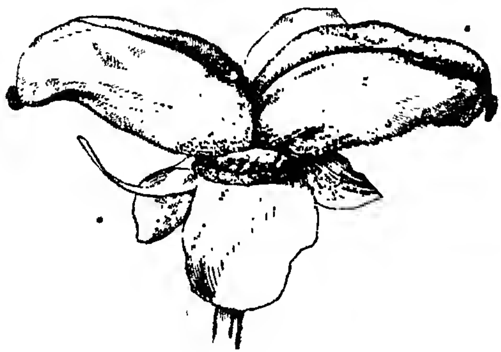


Fig. 56.—Two follicles of Pæony; a dry dehiscent fruit

first to recognise that there are two carpels in the fruit of the Willow or Poplar, and only one in the Laburnum. The surest mode of ascertaining the fact is to look at the unripe fruit, when a single stigma may be seen in the case of the Laburnum, as contrasted with the double stigma of the Willow and Poplar.

The fruits of the Tulip, Hyacinth, Lilac, Wallflower, Stonecrop, and St. John's Wort, though presenting minor differences among themselves, are clearly formed after the same pattern as that of the Willow or Poplar—that is to say, they are dry, dehiscent fruits, consisting of

several carpels, which when mature separate by "valves" more or less completely one from the other. They are therefore all illustrations of capsules or pods. In the case of the Elm and the Ash, the Daisy and the Dandelion, we have also dry fruits, but these do not split regularly, they remain *indehiscent*—the seed escapes from them by the rotting away of the fruit, or by its irregular rupture.

Fig. 57.—Capsule of Violet opening by three valves.

Fig. 59.—Pyxis of Henbane opening transversely.

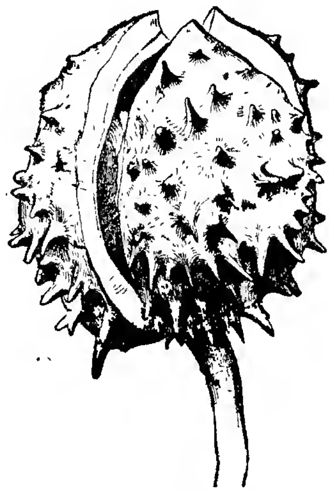


Fig. 58.—Capsule of Horse Chestnut opening by three valves.

In the Rose (p. 59, fig. 32), we have a number of indehiscent carpels like those just mentioned, concealed within a hollow receptacle, the "hip." This latter then, which is usually considered the fruit, is really only the top of the flower-stalk rendered fleshy and concealing the true fruits in its cavity. Compare this structure with that of the Apple or Pear (p. 36, figs. 20, 21), and it will

be seen that the only essential difference between them is that while in the Rose the carpels remain distinct from the "hip," though concealed within it, in the Apple or Pear they become permanently embedded in it, forming the "core." The edible portion then of the Apple or Pear is the receptacle or dilated end of the flower-stalk. In the Strawberry we have a number of small indehiscent

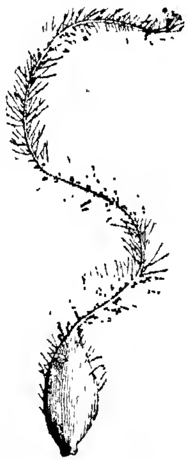


Fig 60.—Achene of Clematis, indehiscent with a long persistent style

carpels like those of the Rose, but the receptacle instead of being concave is convex, so that the carpels stud the surface of the receptacle, and form what are popularly but erroneously called the seeds. The seed is inside these little bodies, which may be recognised as carpels, not only because they contain each a seed, but also because each one is surmounted by a style, which remains attached even when the Strawberry is ripe. A

Cherry or a Peach affords an example of yet another kind of fruit, one in which the middle portion of the fruit becomes pulpy and fleshy, and the innermost portion hard and woody. The stone then of such fruits is the innermost layer of the carpel enclosing the true seed or kernel within it. A Raspberry or Blackberry is nothing but a collection of tiny stone-fruits placed on a raised receptacle—very different thus in reality from the Strawberry with which it is so often associated. A Grape or a Gooseberry may be cited in illustration of another form of fruit in which a portion becomes fleshy and the seeds are embedded in pulp.

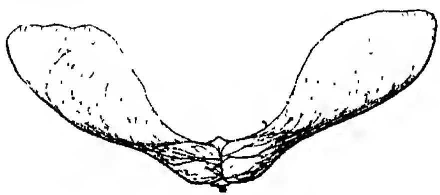


Fig. 61.—Winged Nut, or Samara, of two carpels—Maple.

So far, then, we have dry, dehiscent fruits or "Pods;" dry, indehiscent fruits or "Nuts;" while of succulent fruits there are "Stone-fruits," in which the seed is immediately invested by a woody or cartilaginous stone, and "Berries," in which the seeds are embedded in pulp. We may take these four as common types of fruit-structure. They may be entirely disconnected from other parts of the flower, or they may be more or less confluent with the succulent receptacle, as in the Apple, already referred to; at other times the perianth becomes fleshy and confluent with the fruit, nay even, as in the case of the Mulberry, the whole

of the inflorescence—a catkin—including numerous flowers, each originally with its own separate perianth and pistil, becomes succulent and forms one entire mass. The Pineapple is another exemplification of this merging of the flowers of an entire inflorescence into one mass.

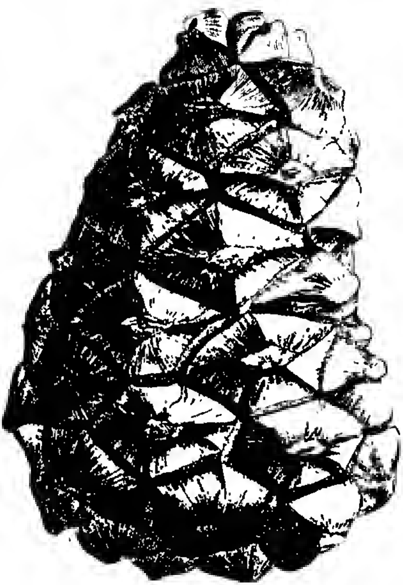


Fig. 62.—Cone of Pinus. Each scale represents an originally distinct flower.

The cone of a Fir, *Pinus*, is of a similar character, save that the constituent scales become woody and not fleshy. Moreover there is this great and important difference between the Conifers (Firs, Pines), and all other flowering plants (except Cycads), viz., that the seeds are not inclosed within any ovary or fruit, but lie on the upper

surface of the flat scales on the cone, or in Cycads on the margins of a flat leaf. We may add by the way that the male flowers of Conifers are of very simple construction, and arranged in catkins; the female flowers also are extremely simple and similarly arranged, while their arrangement in Cycads is so simple, that we might have taken them instead of the Willow as illustrations of flowers of simplest construction, save for the rarity with which they are met with in gardens, and their consequent inaccessibility to beginners. To sum up, then, the diversities in fruits or seed-vessels depend, for the most part, on the following circumstances: the number of the constituent carpels, their isolation or combination, their texture—woody, membranous or fleshy, the way in which the fruits open to liberate the seed, their freedom or amalgamation with other portions of the flower or with the seed (as in Grasses). The great majority of fruits may be explained by reference to one or other of these conditions. It is only necessary for the pupil to make himself acquainted with a few of the terms applied to the commoner varieties of fruit, and these we present in a tabular form, premising that the arrangement is one of convenience only.

A. MONOTHALAMIC FRUITS, *i.e.*, fruits the result of the ripening of the carpels of a single flower or thalamus.	
Texture of the fruit uniform.	
Indehiscent	I. NUTS.
Dehiscent	II. PODS.
Texture of the fruit of varying consistence.	
Seeds within a stone	III. STONE-FRUITS.
Seeds embedded in pulp	IV. BERRIES.
B. POLYTHALAMIC FRUITS, *i.e.*, fruits the result of the blending of the pistils of several flowers .	V. CONES.

Each of these main subdivisions includes sundry varieties, of which the following are the most important.

I. NUTS.	
Wingless.	
Carpels solitary, or, if more, always separate	1. ACHENE (*e.g.* Rose, Dandelion, Daisy, Strawberry, etc.), fig. 60.
Carpels always inseparate.	
Carpels free from the seed . . .	2. GLANS* (Oak), fig. 68.
Carpels adherent to the seed . . .	3. CARYOPSIS (Grasses), fig. 69.
Carpels ultimately separate, but not opening	4. CARCERULE (Borage, Mint).
Winged	5. SAMARA (Elm, Maple), figs. 54, 61.
II. PODS.	
Of one carpel.	
Opening by one edge	6. FOLLICLE (Pæony), fig. 56.
Opening by two edges	7. LEGUME (Laburnum), fig. 29.
Opening transversely	8. LOMENTUM (Hippocrepis).
Of more than one carpel.	
Opening by pores, teeth, or valves .	9. CAPSULE.† (Tulip, Wallflower, &c.), figs. 57, 58.
Opening transversely	10. PYXIS (Henbane, Pimpernel), fig. 59.

* Another peculiarity of the gland resides in the circumstance, that while in the young state it contains three cavities, separated by as many partitions and enclosing each two ovules, in the ripe condition only a single cavity, occupied by a single seed, is met with, the partitions and five of the ovules having been obliterated during the course of development.

† The general term capsule includes many minor forms, of which the siliqua of Crucifers (Wallflower, etc.) is the most important, see fig. 53.

III. STONE-FRUITS.	
Of one or more carpels, bony within and separate or inseparate, but free from the receptacle	11. DRUPE (Cherry).
Of one or more carpels, cartilaginous or bony and enclosed within and adherent to a fleshy perianth, or hollow receptacle . .	12. POME (Apple), figs. 20, 21.
IV. BERRIES.	
Seeds in pulp	12 BACCA (Gooseberry).
V. CONES.	
Woody or membranous	14. STROBILE (Fir, Hop), fig. 62.
Fleshy	15. SOROSIS (Mulberry, Pineapple).

Of all or most of these forms there are special modifications, to many of which names have been given, but those here enumerated are sufficient for all ordinary purposes; to give a greater number would but complicate an already complex subject.

Within the fruit is the Seed, the matured ovule containing the embryo-plant.

As has been already intimated, the embryo-plant is not produced unless the pollen fall upon the stigma. This pollen is usually in the form of minute cells or grains, which gain access to the stigma in some way or another. On the stigma the outer coating of the pollen-cell bursts to liberate the inner coat in the form of a long, very slender tube, called the pollen-tube, which lengthens and passes down amid the tissues of the style till it

* The drupe of the Cocoa Nut and some other plants is fibrous.

reaches the ovules; there, by some process as yet unknown to us, it stimulates into growth a small vital speck, if we may so call it. This speck becomes a cell, that cell divides and subdivides, till at length an embryo plant is formed, of which we shall have more to say in another Chapter, and this once formed, the seed is ripe.

The access of the pollen to the stigma is effected in many ways and with manifold contrivances. The object of all these different contrivances in the majority of cases is to secure the transfer of the pollen from the anthers of one flower to the stigma of another flower of the same kind. Hence, although there are stamens and pistils in the same flower, and which have been likened to husband and wife, the real relationship in most cases is that of brother and sister. Many devices, which we have not space here to detail, are met with to prevent the access of a flower's own pollen to its stigma. Sometimes, when the pollen is ripe, the stigma is immature, or *vice versâ*, or the anthers are so placed that the pollen, when shed, falls out of the way of the stigma. On the other hand every provision is made to attract insects by patches of colour, perfume, stores of honey, etc. Allured by these attractions, the insects visit the flowers, remove the pollen and carry it to some other flower, on whose stigma they deposit it. This matter has been explained when speaking of Orchids. We need only further say that direct experiments have shown that the number and vigour of the seeds and seedling plants within them are much increased when the stigma is fertilised by pollen from another flower,

and, on the other hand, much diminished when the pollen germinates on the stigma of the same flower.

In such plants as the Willow, Poplar, etc. (see Chap. I.), where the stamens are on one plant and the pistils on another, this co-operation of two distinct flowers is of course necessarily secured.

These are facts which should be borne in mind by the gardener in investigating the causes of failure in the 'setting' or fertilisation of grape-blossoms, etc. In what has been said we were referring to the flowers of the same species of plant—it is comparatively rare for the pollen of one plant to produce any effect upon the stigma of the plant of another species; nevertheless, this does happen occasionally, and the result is a '*hybrid*' plant partaking of the characteristics of its two parents, and apt occasionally to lose its piebald character and 'revert,' as it is termed, to the appearance of one of its parents to the exclusion of that of the other, when the plant is said in gardening phrase to 'sport.' Most of the Pelargoniums, Verbenas and other florists' flowers are thus 'cross-bred' or artificial products, raised by the skill and art of the gardener, and very apt to sport back to the original form. It is comparatively rarely that such forms can be reproduced from seed, the seedlings vary from the form desired by the gardener, and hence it is necessary to multiply them by 'cuttings,' or in other words by buds.

In some cases, however, by dint of careful selection, the peculiarities become established and the seedlings reproduce the desired form,—the variation becomes in gardening phrase 'fixed.' The selection referred to

consists in the persistent rejection of those plants which do not come up to the standard wished by the raiser, and in the continued propagation of those that do present the form or colour desired. A florists' flower, then, is as carefully bred and fostered as a race-horse, or a fancy pigeon, and just as it is in the power of the raiser, within certain limits, to produce a breed of poultry with distinctive marks, so it is practicable for the gardener, also within limits, to realise his wishes, whatever they may be, in the case of plants.

It is in this way that superior fruits, improved vegetables, or plants of a better habit, or of a more robust temperament, or which are more productive of flowers and fruits, etc., are constantly being raised. If ill-health or want of vigour arise, it is a sign that the raiser has not experimented judiciously—has made a bad or careless selection, or has persevered too long in one particular direction, and has not sought to gain renewed vigour by an infusion of new blood.

With these remarks as to the history and production of the seed, we pass on to its appearance in the ripe state. Every one must have remarked the astonishing variety in their form and appearance. Hard seeds, soft seeds, round seeds, flat seeds, seeds angular, seeds cylindrical, seeds as large as an ostrich's egg (cocoa-nut), seeds so small that they might well be mistaken for grains of dust, seeds as smooth as the bore of an Armstrong gun, seeds beset with spines as thickly as a hedgehog's back, seeds pitted like a honeycomb or as thickly studded with pimples as Bardolph's nose, now covered with long silky white hair (cotton), in other plants invested with thick,

close felt, or encircled by a membranous wing; now nestling in juicy pulp, again wrapped round in a fine scarlet mantle or arillus (Nutmeg, Spindle-tree). There is really no end to the varied appearances of the seed; and if, to go a step further, the microscope be turned on

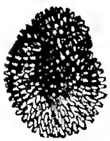


Fig. 63.—Tubercled seed.

Fig. 64.—Annulate seed of Larkspur.

Fig. 65.—Netted seed of Poppy.

Fig. 66.—Pitted seed of Stavesacre.

it, what a wealth and variety of form and disposition in the cells of its outer covering, every whit as much diversity in internal organisation as in outward conformation!

Some of these diversities in outward appearance are accounted for by the necessity for dispersal, thus, the 'winged' seeds or those furnished with feathery rafts of fine hair (fig. 55), are borne by the winds, others with spines or hooks get dispersed by clinging to the fur of animals and so on. But after all these obvious provisions there remains a large residuum of unexplained forms which we can only marvel at and observe, in the hope of penetrating the mystery at some future time. The inner structure of the seed and the embryo within it, we leave to the next Chapter.

CHAPTER VIII.

Seedling plants—The ACORN—Dicotyledons—Monocotyledons—Germination—Conditions requisite for—Embryo, its parts—Cotyledons, Radicle, Plumule—Growth continuous, definite or indefinite—Wheat-grain, its structure—Albumen—Habit of stem and root dependent on diversities of growth—Growth in lines, in planes, and in spheres, continuous and interrupted, regular, irregular, and periodic—Relation of growth and form to the uses of the several parts—Direction of the branches—Growing points—Roots, tubers, etc.—Compensation.

IT is absolutely essential to any one who wishes to know something of botany that he pay heed to the mode of growth, and to the forms of roots, stem, or leaf. These points are too often neglected by the beginner and the amateur, owing, perhaps, to the superior attractiveness of the flower over the other parts of the plant. No one with a real love of his subject will allow of such a plea; moreover a very little study will show that the lessons to be learnt from these less gaily bedight organs are to the full as important as those taught by the flower. They are of cardinal importance to the right understanding of the flower; and, they can be studied at all times and seasons.

As we are now about to deal mainly with the form assumed by the stem and root, and with the arrangement of the branches and leaves, it is as well to begin at

the beginning, and to cast a glance at the baby plants as they emerge from the seed. Our countryman, John Ray, was one of the first to discover and make known the great importance of attending *to seedling plants.* Some things, like a tropical Orchid of great price, are important from their rarity; other things, like the humbler Cabbage, are important from their frequency. It is in this latter sense that seedling plants are valuable to the botanist, and John Ray had the sagacity to see that, so far as constancy is concerned, there was no better mode of grouping the entire mass of flowering plants of all sorts and descriptions than that furnished by the seedling plants. Speaking broadly, and disregarding for the moment exceptions too few in number to affect the general result, all flowering plants may be ranged under two categories, those whose seedling plants have one seed-leaf, and those which have two of equal age. These seed-leaves are known as *cotyledons;* and plants with one seed-leaf are called *monocotyledons;* those with two, *dicotyledons.*

The importance of this distinction is shown not only by its very general—almost universal—application, by its constancy as a botanist would say, but by the fact that this arrangement is almost invariably associated with other marks of difference between the two groups; and so we have cumulative evidence as to the distinctness of the two. For instance, Dicotyledons have almost invariably net-veined leaves (see p. 31) and the parts of their flower arranged in fours or fives, or some multiple of those numbers (see fig. 38, p. 75), their wood, when they have any, is arranged in annual zones, zone

over zone, from the centre outwardly; while Monocotyledons have—barring a very few exceptions—straight-

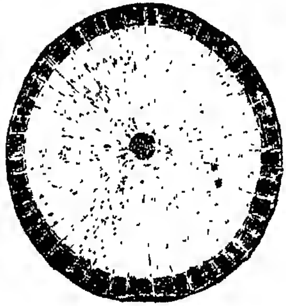


Fig. 67.—Branch of Dicotyledon with eight zones of wood within the bark around the central pith.

veined leaves, the parts of their flowers are in threes, and their wood is not arranged in zones, not to speak of other characteristics. This is enough to show the importance of paying some attention to the seedling, and there is this consolation, that when a seedling cannot be got, its general characteristics can be pretty safely inferred from the leaves, or flowers, or wood, as just mentioned.

To illustrate the two forms of seedling, our artist has delineated a seedling Oak (fig. 68) and a seedling plant of Wheat (fig. 69), and we will advert to the more important features of each, premising that the beginner need not experience much difficulty in seeing these things for himself.

Grains of Wheat are easily procurable, and acorns in due season; failing them, a Broad Bean or a Pea will serve the purpose equally well. Let some of these be sown in moist earth or sand in a flower-pot, or in damp moss or

sand, and kept in a moderately warm place, and soon the life within the seed, at first not obvious, will make itself seen. It is a capital plan to suspend an acorn or other large seed in a bottle half filled with soft water; so that the seed just touches the surface of the water. Put the bottle into a dark cupboard for a few days, for the exposure to full sun is not propitious to the first stages of plant growth; and when the shell cracks open and a root makes its appearance through the rent, then the bottle may be brought out from its obscure retreat, and the whole further process of germination witnessed.

The shell of the acorn is the true fruit—the ovary arrived at maturity, and greatly changed in appearance from what it was when it nestled like a tiny egg in the nest-like cup then bigger than itself, but since by comparison dwarfed. Within the shell of the acorn is the seed proper, whose structure we have now to explain. If an acorn be not at hand, a Bean or an Almond will answer the purpose as well, especially if previously soaked for a few hours in water.

The great mass of the acorn consists of two thick fleshy lobes, rounded on one surface, but flat where they come into contact one with the other; these are the two seed-leaves, the cotyledons, thick and fleshy, because they are the store-houses of food whence the young plant derives its supplies before the root and leaves are able to supply its requirements (fig. 68, A, A). The seed-leaves are not always like those of the Oak. In other cases they are thin and green, soon pushed up above ground to fight for themselves, and differing but little, save in contour, from the ordinary leaves of the

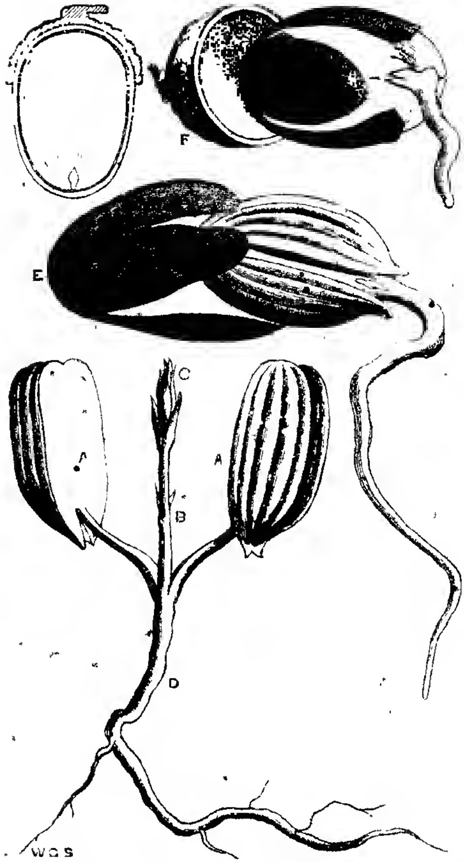


Fig. 68. ACORN IN VARIOUS STAGES OF GROWTH.—The upper left-hand figure shows an acorn cut through the middle : at F, is shown the acorn partly removed from the cup and the radicle protruding from the acorn, the outer shell of which is the fruit proper. At E, the seed is shown detached from the fruit, with the radicle still further developed. The lower figure shows at A, A, the seed-leaves ; at B, the portion of stem above the seed-leaves . at C, the young bud or plumule ; above D, is the portion of the stem below the seed-leaves (caulicle) : and below D is the radicle, or primary root.

plant, indeed, fulfilling the same office as they do. Now, supposing that there is but little nourishment stored up within the tissue of the seedling plant, or within the seed investing it, it stands to reason that the seedling must quickly shift for itself, or succumb for want of proper nourishment. This is one reason for the quicker germination of some seeds than others; for instance, the common Mustard germinates very quickly, as every one knows. It sends its roundish, notched seed-leaves up above ground into the light and air with all possible despatch, to get food for the young plant.

These are the leaves eaten as Mustard, with the corresponding leaves of the Cress, as salad. Reverting to our acorns, we see closely packed, between the two seed-leaves, a little oblong mass, at one end of which rudimentary leaves are readily seen, while at the opposite extremity is a root.

When the seedling Oak begins to grow, the first part to break loose from the investing seed, as also in all other plants, is the root. Given a sufficiently high temperature, an adequate supply of air and water becomes a prime necessity; and in order to get and appropriate it, the root descends—always descends—it may ascend for a time if put out of its course by any obstacle, but left to itself down it goes—a pretty good mark of a root: and note, it goes down continuously (provided there be no obstacle) as long as there is any necessity for it to do so. It is not arrested in its course, but continues to go on in the same direction as that in which it started—that is an example of continuous growth. In other instances, as we shall see by-and-by, growth proceeds in

one direction for a time, and then, from some cause or another, it becomes checked; and if renewed it goes on in another direction, at an angle to the former line of growth, perhaps in an altogether different plane. Here we have illustrated two facts never to be lost sight of in studying plant growth—the continuous or indefinite as contrasted with the arrested or definite mode of growth.

The root of the acorn, under natural circumstances and if not interfered with, developes into a tap-root, a valuable form for anchoring a plant in the soil, but not so desirable in the eyes of the nurseryman, who has occasion to shift the young plants, and hopes ultimately to transfer them altogether to fresh fields and pastures new; for this purpose a tuft or leash of roots is better than a single one. In transplanting there is less chance of cutting off the supplies when there is a tuft of fine feeders than when there is but one; hence it is a not unfrequent practice to pinch or cut off the end of the tap-root, after a little while, when a number of fibres or thread-like roots are developed, to carry on the work heretofore conducted by the one tap-root.

At the opposite extremity of the seedling plant are, as already said, the rudimentary leaves (fig. 68, C), packed in what is virtually the first bud. As this grows it lengthens upwards in a direction precisely opposite to that of the roots; the latter want water, and go down in search of it; light and air are essential requisites for the leaves, and they are thrust up to seek these life-giving elements. We know the fact, we know the

object of this upward and downward growth respectively, but the way in which it is done is still, despite many curious experiments and much hazy speculation, obscure. Now it is a canon in botanical science that whatever bears leaves and buds is a stem, or a part of a stem, a branch, and that, per contra, a root never bears leaves and buds (always making allowance for occasional and rare exceptions); hence in our seedling Oak, that portion to which the seed leaves are attached, and which bears the young bud, is to be accounted stem, and that portion which bears neither leaf nor semblance of leaf and goes down is root. Thus, in our illustration (fig. 68), the space from D to B is to be considered as stem (*caulicle*), bearing two seed-leaves, A, A, and a terminal bud, C, sometimes called the *plumule*. The portion below D is the *radicle*, or true root. It will be noticed that the portion from D to B tapers upwards, while below B the tapering is from above downwards. This outward difference of appearance corresponds with an inward difference of structure.

The grain of Wheat and the acorn have this in common—that they are neither of them seed. Most people unversed in botany would class them as such, but this is one of the many vague and incorrect notions which the botanical student has to rid himself of. Both invest and contain the seed, but are themselves no more to be considered the seed than the case of a watch is to be held as a timepiece. The acorn, as previously explained, is the seed-vessel. The outer skin of a grain of Wheat or other cereal in like manner is the seed-vessel.

In botanical language, the "fruit," or "seed-vessel," is, as has been already explained, that which immediately contains or invests the seed—it is, in fact, the pistil or ovary of the flower, more or less altered in character during the ripening of the seed. By referring to the description and illustration of the Wheat (fig. 69), this statement may the more readily be comprehended. To see for oneself the structure of a Wheat grain, which is what every one should do who wishes to have a clear knowledge of the subject, a few grains should be soaked for some hours in water; or, better still, they should be induced to germinate, and all the stages of the process watched.

It has already been mentioned how this can be done in the case of an acorn or a filbert suspended in a bottle, and we may now commend to the notice of those of our readers to whom it may not be known an equally simple method of growing their own Wheat on the chimney-piece, where it will form an object of great interest to the young folk, and a pretty ornament during the dull season. All that it is necessary to do is to secure some ears of Wheat, with a portion of the straw to serve as a stalk, and to plunge these stalks into some sand or moss placed in a vase or bowl, so that the ears project above the surface of the sand. The sand should be kept constantly moist, and the vase should at first be placed in a dark cupboard till the germs begin to sprout, when it may be moved on to a mantelpiece or into a window,—anywhere, in fact, where it will get a moderate share of light and warmth. We once had a bowl of this description with a dome of sand in the centre, which,

when covered with the green sprouts of the Wheat, presented so much of the aspect of the odd-looking ornament on the top of the Monument near London Bridge, that we were almost tempted to suppose the architect took his idea from a mass of germinating Wheat grains in a bowl! To revert to our Wheat grain. Let the pupil take one that has been duly soaked, or which has only just commenced to grow, let him slice it in half lengthwise, as has been done at fig. 69, A B C. He will then see that the great bulk of the seed is made up of a floury mass, at one end of which is a little body, the embryo (B C), which wants a little looking for on the part of a beginner unaccustomed to use his eyes, but which may be recognised by its different texture and colour, and which, as growth proceeds, will force itself into recognition by the importance of the changes it undergoes. The floury mass is the *perisperm*, or albumen, and is the inner portion of the seed; its "floury" character is due to the circumstance that it contains a quantity of starchy material, stored up in anticipation of the wants of the seedling plant.

Comparing this arrangement with that of the acorn, it will at once be seen that the seed proper in the Oak contained no store of nutriment corresponding to the albumen of the Wheat, and the embryo plant filled up the whole of the seed, instead of occupying a little notch at one end. The seedling Oak is thus independent of the seed from the time it begins to sprout, even as a young chicken asserts its independent existence almost immedlately after it is liberated from the eggshell. The

seedling Wheat is not so precocious, it is more like a helpless kitten, and is dependent on its mother-seed for its supplies for some time. Of course, this analogy must not be pressed too far. The fact is, the necessities of the seedlings in the two cases are equally well provided for—the one is no more really independent in its early stages than the other. The difference between them is merely this, that in the Oak the food for infants—true farinaceous food—is stored up in the tissues of the seedling itself, which thus, as it were, lives on its own resources, while in the Wheat the nutritive matter is contained in the seed and not in the seedling. After this explanation it is easy to see why the seedling Oak has such sturdy proportions almost from the first, while the seedling Wheat, on the contrary, is so tiny in its dimensions.

In order clearly to see the parts of the seedling Wheat, and to trace its mode of growth, it is advisable to take a grain that has not merely been soaked, but one which has begun to germinate, as has been done in the case from which fig. 69, D, was taken. Now compare this seedling with that of the Oak (fig. 68). In the Oak is a central stem or axis bearing, one on each side of its centre, the seed-leaves, and terminated above by a bud, the *plumule*, which thus emerges from between the seed-leaves, and ending below in a well-marked radicle or root, which tapers gradually from above downwards. In the Wheat there is a similar central axis, but it is comparatively very short. It bears on one side a single seed-leaf (*monocotyledon*), see p. 120, concealed within the seed, the lower part of which forms a sort of very short

sheath around the stem, and out of which the first bud or plumule emerges in such a manner as to appear to spring from the side of the seed-leaf, instead of from the end of the stem, as it does in reality.

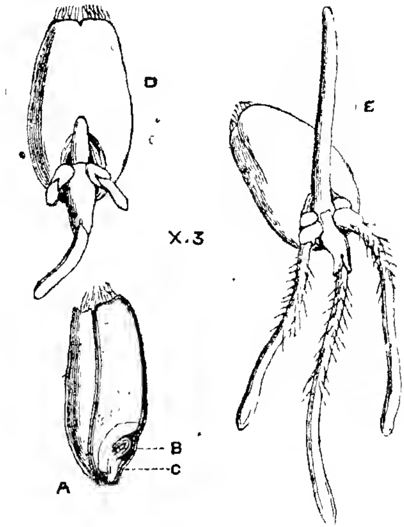


Fig. 69.—A, Grain of Wheat from which a slice has been taken to show the interior; B, Plumule; C, Radicle; above B is the solitary cotyledon at the base of the albumen, the latter marked by fine dots in the engraving; D, Early stage of germination, the cotyledon is retained within the grain, the plumule is shown ascending, and three root-fibres are protruding through their root-sheaths; E, Further stage of germination showing the root-hairs.

Below the seed-leaf the stem scarcely tapers at all, neither does it perceptibly lengthen. The true root, then, is by some supposed to be absent in these cases. Probably it would be quite as correct to say that the root of a monocotyledon does really exist, but that instead of lengthening, as in the case of a dicotyledon,

it is subjected to an arrest of development. Whether this be so, or not, the fact remains that a tap-root, such as we see in the Oak, has no existence in the Wheat, and that in the latter case the office of the root is filled by a number of fine threads, which gradually emerge from the root-end of the seedling Wheat (fig. 69, D E), pushing before them the skin, and ultimately breaking it so that each root-fibril passes through a sheath—a circumstance very characteristic of the root of monocotyledons, but very rare in those of dicotyledons. These root fibres of the Wheat rapidly branch and subdivide, so as to be able to avail themselves, so to speak, of every particle of soil, or rather, of every droplet of water intervening between these particles, as it is well established that roots absorb liquid and gaseous nourishment only, and have no power of taking up solid matters however fine. It is the smaller finer roots and the root hairs (see fig. 69, E) by means of which absorption takes place. Every provision is made in the case of the Wheat for rapid growth, rapid feeding, and rapid reproduction. The *rôle* to be played is quite different in this respect from that which has to be enacted by the acorn, where deep anchorage, slow growth, and firm wood have to be secured years before it becomes necessary to produce acorns. This question of root-growth is one of the most important that can occupy the attention of gardeners and farmers, but it is one that has not been sufficiently attended to.

We have now indicated the differences between a dicotyledonous and a monocotyledonous seedling, and we have shown (pp. 31, 34) how these differences are asso-

ciated with so many others to render it possible to group all flowering plants — barring exceptional instances too small in number to be worth considering from this particular point of view, though in themselves most worthy of attention,—into the group of *Monocotyledons* to which the Wheat, the Tulip, the Hyacinth belong; and *Dicotyledons*, under which the Willow, Poplar, Ash, Daisy, and other plants that have been illustrated in these pages, may be grouped. The main structural features, however, on which we would lay stress, in the case of the seedling Wheat, are these—the *alternate* arrangement of the leaves, as manifested from the very first in the single cotyledon, and the *definite* growth of the root (or at least of the root-end of the stem). It is worth while calling attention to these principles of growth as here shown in a simple condition, in order the better to understand the working of the same principles in their more complicated manifestations in the course of the growth of the tree or shrub.

Some of the main characteristics met with in adult stems and branches are hence quite distinguishable even in the seedling. In previous chapters other illustrations of what is meant by definite and indefinite modes of growth have been given, and explanations of the conditions to which botanists apply the terms alternate, opposite, decussate, and the like. So far, then we hope to have cleared the ground for the comprehension of the different forms which the stem and its subdivisions assume in different cases. To enter into detail

on these matters would demand a bulky volume; besides, it has been our object throughout to keep the general principles of plant-construction before the reader, and to give him only such an amount of detail as shall insure his due comprehension of the principles. These mastered, their application to particular cases is a matter of comparative facility. It may suffice to recall some of the diversities of aspect or "habit" of shrubs, of trees, or of herbs, *e. g.*, the spreading Cedar, the tapering Poplar, the "weeping" Willow, the mop-headed Robinia, the dumb-waiter-like arrangement of the branches of Araucaria, the fat bloated-looking Echinocactus, the snaky Cereus, the twining Hops, the globular bulbs of the Hyacinth, the dense rosettes of the Sempervivum, and—but the variety is infinite. The causes bringing about all these modifications are as simple in nature as they are few in number. "'Spects I grow'd," said Topsy, and to growth, and cessation of growth, in various directions and degrees, and at different periods of time, may such diversities as we have alluded to be attributed. Let us explain. There is *growth in lines*, where development takes place principally in the longitudinal direction—a reed, or the long unbranched stem of a Palm, sufficiently illustrates our meaning; there is *growth in planes*, the masses of Duckweed (Lemna) floating on the first pond you come to, or a leaf off the nearest plant, will sufficiently exemplify that mode of growth. There is *growth in spheres*, perhaps the most important and general of all methods, at least at first. Suppose food and other requirements to be in equal quantities, and the facilities for getting them also equal on all sides—and this is

pretty much the case in the earliest stages of life vegetable or life animal—and the growth will be spherical. Suppose, on the other hand, there is more food in one direction than in another, the great amount of growth will be in the direction of the supply. So, if one kind of food, light, and air, be in one direction, and another kind of food, water, and earthy matter be in another, there is an obvious reason why the primitively globose form should be replaced by a linear shape, better adapted to fulfil the requirements of the case. Again the flat (plane) shape of the leaf is that best adapted to secure the absorption and giving out of gases, which form so important a part of the duties of a leaf, and which demand for their successful fulfilment ample exposure to the air and to light.

Growth, then, is intimately dependent on food, the mode and direction of growth on the nature of that food, and the place wherein it is to be found. Further, given the food, given also the means of getting it, no plant—no living being, be it what it may—lives entirely for itself. It lives with, in, for, amongst other beings, in harmony or in hostility with them. Erasmus Darwin sang the "Loves of the plants;" his descendant, Charles Darwin, has become the historian of their wars; and besides all this reciprocal help or antagonism of plant and plant, as the case may be, there are the varying conditions of atmosphere, of climate, of soil, and all these are calculated to modify the growth of plants. And then it must be remembered, that these modifying circumstances do not act singly, or one at a time, but in combination, and thus endless complexity and innumerable compromises

are brought about. The general result of all this is to be seen in that marvellous variety of form, that wonderful adaptation of living creatures to the circumstances around them, which compels the most thoughtless to exclaim, "The hand that made them is Divine."

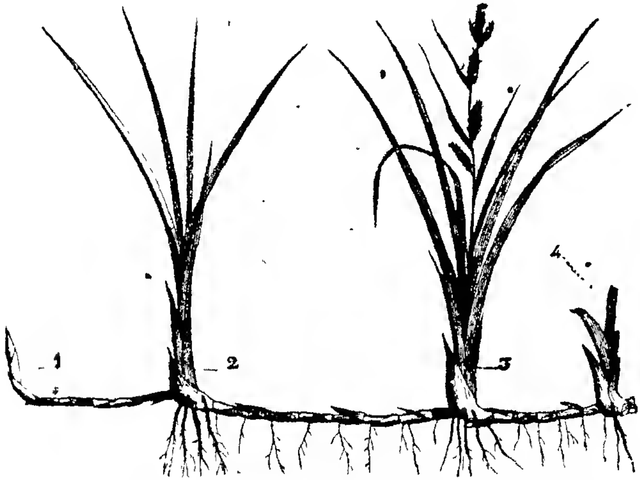


Fig. 70.—Creeping stem or "rhizome" of CAREX, showing four generations of growth. The creeping stem gives off buds from the upper surface and roots from the lower.

Starting then with the sphere as the primitive form, and the line and the surface as the immediate derivatives from it, and bearing in mind the infinite variety of modifying conditions, the causes of the forms of stems, including here roots and branches, are not far to seek. Growth may be continuous and uninterrupted*—in-

* It must be understood, of course, that these expressions are used in a relative sense.

definite, in fact; and then we get a straight unbranched erect trunk, or a long trailing shoot. On the contrary, a check may come and then the growth is arrested. That arrest may be permanent, or temporary only; if permanent, the form of the tree or shoot is of necessity profoundly modified in consequence, and we get the series of forms known as definite. If temporary, the shape is not necessarily modified, the arrest may be periodic, that is to say, there may be alternating periods of growth and of arrest of growth. It is so with our trees in winter, when their growth is arrested—in spring extension is resumed. If there should happen to be a bud on or near the end of the shoot, the direction of the growth will be the same as in the preceding season, and the general form will not be altered, as in the underground stem of a Sedge, shown in fig. 70, but if there be no terminal bud, or if it be injured or removed by some accident, or from any cause growth becomes arrested, then the new growth in the following spring will be in another direction, as in the "rootstock," or underground stem of the Iris, shown at fig. 71. Take as another illustration the tier upon tier arrangement of branches in many Conifers, such as the Araucaria or the Norway Spruce. The "habit" here is very striking, and it is brought about by periodic alternations of growth and arrest of growth: the main stem grows continuously, the side branches are developed at regular periods, and arrested in the intervals.

Another cause producing great variations in the forms of stems is to be sought for in the unequal amount of growth in some directions as contrasted with that in

others. In a bush or shrub the amount of growth in all the branches is nearly equal—all the older branches

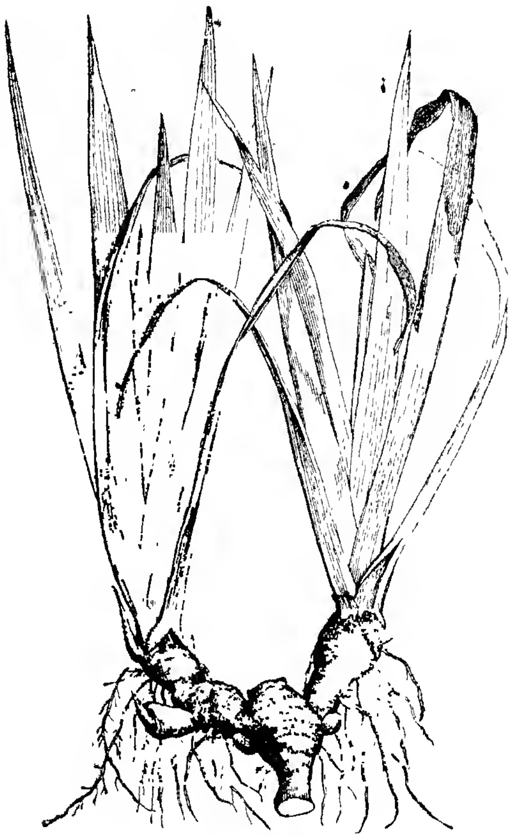


Fig. 71.—Definite Rootstock of IRIS.

are therefore of about the same size, but in a tree with a lofty unbranched trunk, a Scots Fir, for instance, the

growth of the trunk is, at least for a time, much more pronounced than that of the branches. Again, the main development may at one time be in one direction, at another time in another, and so great varieties of shape are produced. Let us take a bulb, such as that of the Hyacinth or the Tulip, before referred to, or a plant of any House-leek (Sempervivum). In any of these the growth of the leaves or of the scales, which are the representatives of leaves, is in excess of that of the stem bearing them; this latter remains short and contracted, the internodes, as they are called, *i. e.*, the spaces between the nodes or points of emergence of the leaves from the stem, are not developed, and the result is what is commonly called a stemless plant. The Daisy and the Dandelion afford illustrations of the same thing. The term "stemless" is, as we have seen, botanically incorrect, for the stem is that portion of the plant bearing the leaves—it may be very short, but there it is; and the proof of this assertion may be seen when the flowers are produced—up goes the stem to bear aloft the newly formed flowers, and very often leaf separates from leaf in the process; the internodes, no longer undeveloped, manifest their presence unmistakably (see fig. 75). In the cases just mentioned, the growth of the leaves, for a time at least, is greater than that of the stem. In the Cactus, or in the succulent Euphorbias (fig. 35), the reverse is the case. The stem grows, and the leaves are undeveloped, or appear only in the guise of spines.

Look, too, at the figure of the Japan Primrose, *Primula japonica* (fig. 72). It shows arrest of growth in the lower part of the stem, causing the leaves to be closely

packed in tufts on the surface of the soil; the arrest is not permanent, however—the flower stem rises to

Fig 72.—JAPAN PRIMROSE, much reduced, flowers natural size.

bear in all its majesty that mass of flowers which has secured for the plant the title of Queen of the Prim-

roses. In the arrangement of the flowers of this plant, too, we see the principle of growth and arrest of growth manifested; a tier of flowers, then an interval, again a tier of blooms, and so on, just as in the Araucaria or the Spruce Fir above alluded to.

Another circumstance which greatly modifies the form of the stem and branches, is the direction which those branches assume—now horizontal, at other times ascending or descending more or less obliquely, and producing thereby the various forms of round-headed, fastigiate, or weeping trees, and their many modifications. We cannot enter into the explanation of all these forms, suffice it to say, in general terms, that the form assumed is that best calculated to favour, not one particular leaf or set of leaves in their struggle for light and air, but the whole mass of the foliage, and to place each leaf in such a position that it shall infringe the least upon its neighbour's space, best accommodate itself to the exigencies of the situation, and most completely serve its office of feeding the plant and building up its stem. In this struggle, and in this process of adaptation, the weakly leaves and buds die and fall off; others, badly placed, or of necessity overshadowed by those more favourably located, also fall to the ground, the buds in their axils remain undeveloped, and thus again the form of the stem and its subdivisions becomes modified.

The different positions of the leaves and buds—alternate, opposite, whorled—have already been alluded to. The reader will need no further reminder as to the influence of the varying position of these organs on the

form of the plant as a whole—all this has been told in previous chapters.

It only seems requisite further to point out that the branching is not necessarily the result of the growth and extension of buds placed in particular positions, because in the case of the true root there are in the majority of cases no buds, certainly no terminal buds, and any subdivision that takes place must be the result of the forking of the growing point. But a "growing point" is in nowise different from a bud, except in the absence of investing scales, which indicate a periodic arrest of growth, as before explained, and which is not so noticeable in the case of a naked growing point as it is in that of a bud properly so called.

In immediate relation to the forms assumed by stems and roots is the necessity, in certain cases, of providing store room for water, for starch, or other products not immediately required, perhaps, but which will be wanted in the future for the supply of the tissues when growth commences, or for the use of the flower when its development begins. This necessity is provided for by those rounded succulent formations which we call tubers, pseudobulbs, bulbs, and the like. Sometimes these are dilatations of the true stem, or of the branches, or of the buds (Potato), or of the roots themselves. In other cases they are of a compound nature, as in the tubers of the Orchis (fig. 73), which are partly root, partly bud-structures. Their purport is pretty much the same in all cases; their intrinsic nature, as we have just seen, is very varied.

A last word as to the roots: the modifications in

their form are due to pretty much the same causes as those already alluded to. A remembrance of the different offices the subdivisions of the root have to fulfil will serve to explain all the rest; the larger ones are anchors or holdfasts, and their size and direction are in accordance with their functions, and the nature

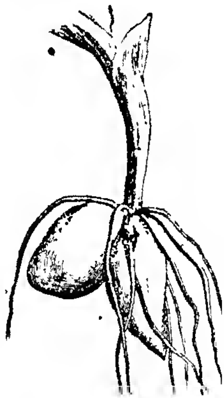


Fig. 73.—Tubers of Orchis

of the soil they are growing in; the smaller ones—the feeding roots—active, busy fellows, are to be found everywhere where healthy food is to be obtained, their tiny dimensions enabling them to absorb the liquid food from crannies often too small to be seen by the naked eye. Here, again, varying conditions of soil, and varying forms or qualities of root, are found, as might be expected, in association one with the other.

The illustrations accompanying this Chapter, some of

which have been copied from a recent part of M. Baillon's "Histoire des Plantes," will suffice to explain much that we have alluded to in this article. Thus in fig. 74 we have the Kohl Rabi with its "tap" root surmounted by a

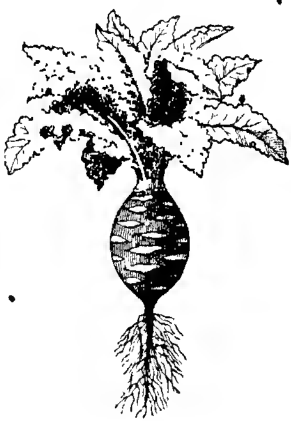


Fig 74 —KOHL RABI

globose stem; we know it to be stem, for it bears the scars of fallen leaves. In this Turnip-like mass is a store of nourishment available for use in building up the inflorescence and flowers. At the top of the stem is a tuft of leaves closely crowded together, because the growth of the stem between them is for the time arrested. We say for the time, because it is evident from an inspection of the scars below that the stem has already grown between the leaves causing their separation one

from another, while should the plant produce flowers, as shown in fig. 75, the stem will again grow chiefly in

Fig 75.—Kohl Rabi in Flower.

length, the leaves will be spaced out, and lateral branches will be produced till a bushy pyramid of flowers is formed.

In fig. 76, representing the Savoy, we have an unbranched stem, which does not swell out, as in the Kohl Rabi, but, by way of compensation, produces a tuft of large leaves. This incidental mention of *compensation* bids us to remind the reader to remark the

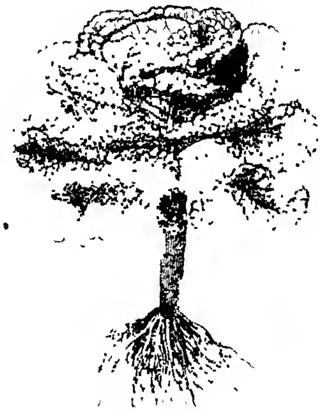


Fig 76.—S VOY CABBAGE

almost universal application of this principle in plants. If one portion of a plant be very large, some other is proportionately small, and so on.

In fig. 77, showing the "Brussels Sprouts," we have a case wherein the lateral buds—"sprouts"—are more numerously developed than usual, and also larger in size;

their growth is usually more or less arrested—here it is allowed full play.

Fig 77.—BRUSSELS SPROUTS.

In fig. 78, representing the Cauliflower, we have a stem and tuft of leaves similar to those of the Savoy, but the inflorescence is arrested in its growth. Call you that

great fleshy succulent mass an instance of arrest of growth? we fancy we hear some one say. We have only to look back to fig. 75, however, to demonstrate that it is an arrest of growth. The flower-stalks do not lengthen, and even the flowers themselves are for the most part imperfectly formed. But by compensation

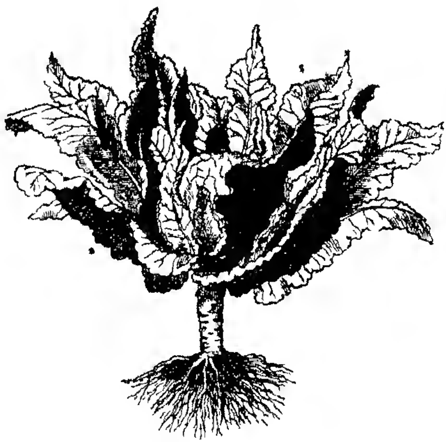


Fig 78 - CAULIFLOWER

what is lost in one way is gained in another, and in place of the pyramid of stick-like branches we have that succulent vegetable mass so highly appreciated on our dinner-tables.

It may be readily inferred from the above examples how important a study of the mode of growth of particular plants is to the cultivator. Success or failure in such matters as pruning, the management of fruit or

forest trees, the cultivation of vegetables of all kinds, and even the extirpation of weeds, depends on a thorough knowledge and practical understanding of the mode of growth natural to each plant, and of the manner in which it can be modified to suit the wishes of the gardener or farmer.

CHAPTER IX.

Classification of plants—Its object—Means of carrying it out—Characters, their nature and value—Mode of estimating their value—Constancy, invariability, physiological importance, congenital value—Individual —Species—Genus—Order, &c.—Probable origin of species by descent —Specific and generic names—Natural system of classification—Artificial system—Analytic system—Descriptions of plants—Points of contrast or resemblance to be looked to in each organ.

ALTHOUGH we cannot within the limits of this volume pretend to enter, at any length, either upon the physiology or the classification of plants, yet, as these are inseparably connected with the subject which occupies the principal portion of these pages, we cannot wholly pass them by.

The physiological uses of the various organs of plants have, indeed, been incidentally alluded to, and will be more fully discussed in the following Chapter; while such expressions as *species*, *variety*, *order*, and the like, have of necessity found a place. It is to these latter that we would now devote a few words. The main object of classification is to arrange plants (or animals) into groups, so that they may be readily recognisable. The botanist endeavours to do this by placing together, according to the extent of his knowledge, those plants which he thinks are most alike, and by separating most widely those he thinks most different. In so doing he has to make use

exclusively of those marks or "characters," as they are termed, which we have dwelt on in the description of the several plants in the foregoing pages. Certain of these marks are common to a great number of plants, certain others are only found in a few; the former are useful in characterising large groups of plants, while the latter are serviceable in distinguishing the members of smaller communities. We see then that some of these marks are much more frequently met with and hence are more highly valued by the classifier than others.

If this frequency of occurrence were the only thing to be considered, the allotting of plants into appropriate groups would be an easy matter; but there are other things to be considered, such, for instance, as invariability. If a particular mark be subject to much variation in particular instances, its value is impaired in spite of its frequency of occurrence. It is this circumstance which leads botanists to endeavour to estimate the *value* of their marks. They do this by taking into consideration, not only the frequency of occurrence and degree of constancy of the mark or character, whatever it may be, but also its physiological importance; for example, a leaf is of higher value as a character than a petal, because it is more frequently met with, and because it is more essential to the life of the plant. A stamen would have precedence over a petal, for the same reason. Those organs or parts which are of vital importance to the plant, either for feeding purposes or for the multiplication of its kind, furnish marks of greater importance than others, and these characters are therefore made use of to distinguish the larger groups. It must be further stated

that these essential characters are formed first in all plants; while the minor peculiarities which have no primary influence on the life of the plant, but only modify its processes, appear afterwards. It is in this way that a flower which in adult life is highly irregular, from one or other of the causes already mentioned, begins its existence, like most other flowers, in regular manner. The irregularity does not occur till a comparatively late stage in the plant's life. On this account therefore such marks as we know originate the earliest, and which lay down the framework, so to speak, of the flower, are of more value as characters than those which manifest themselves later, and which are of special value only to the particular flower in which they appear.

These things being premised, let us now see how they are applied in practice. We start with the *individual* plant, Willow, Rose, Cabbage, or whatever it may be. Presently we find a number of Willows, Roses, etc., of the same general appearance, so like the individual we first selected, that the mind recognises them all as being of one kind: on this recognition the naturalist founds what he calls a species. By-and-by, we may find some other individual plants differing from the preceding in some points, but still sufficiently like them to be called by the same name. Thus there are many kinds of Willow or of Rose: the terms Willow and Rose then represent a number of different kinds of Willow or Rose, the whole constituting a *genus*. Poplars form another genus, evidently very close to Willows; the two genera constitute an *order*: and so in like manner orders are grouped into *cohorts*, *sub-classes*, and higher groups still. For

convenience sake, names are given to genera and species—specific names to the one, generic to the other. Thus, the generic name of the Willow is *Salix;* and the species are named according to some peculiarity, such as *S. alba*, the White Willow, *S. fragilis*, the Brittle Willow, and so forth; or in compliment to some botanist who has studied Willows, or done something to advance botanical science, *e. g.*, *S. Smithiana*. The general rule followed in this latter case is to adopt the termination *ana* when the designation is a mere compliment, and that of *ii* when the person whose name is employed has been the first to discover or describe the particular species: thus the name *Salix Smithii* would indicate that the Willow in question had been described or discovered first by a botanist of that name. Before the time of Linnæus plants were not called by two names, that of the genus and that of the species, but were distinguished by short descriptive phrases very inconvenient to use, especially in conversation. The generic name, as now used, corresponds to the family or surname, the specific name to the christian name. Orders are named from some prominent genus, thus *Salicaceæ* from *Salix*, the termination *aceæ* being in general use to designate an order. Where two botanists have given a different name to the same plant, the two names are used as synonymes; but in all cases, where there is no doubt about the matter, the name first given is preferred to any other.

A species cannot be accurately defined; to a great extent it is an arbitrary creation of the naturalist; so is a genus, so are the other groups; hence naturalists differ among themselves as to the limits of the groups in

question. There is nothing absolute about any of these groups, and therefore there is the more room for liberty of opinion. In order that this liberty should not degenerate into license, which would be the ruin of the science, naturalists agree among themselves to consider a species as a number of individual plants more like one another than they are like any other individuals. A genus is a group of species having the same degree of relationship one to another; an order, a group of genera, and so on. Moreover, the individuals of a species give origin by means of seeds to other individuals like themselves. The child resembles its parents so much as to ensure the recognition of its parentage. A species then is said to reproduce itself. And so it does in many, perhaps most cases, so long as the conditions remain the same; but still there is a great degree of variation in certain individuals, and when we find one plant presenting certain marks belonging to one species, and certain others belonging to another, we infer one of two things, either that the plant in question is a hybrid or cross bred (see p. 116), or that the two supposed species are really one, or were, at least, derived from one common stock. In fact, the natural system of classification—that in which we attempt to arrange plants according to the greatest degree of resemblance—*is an attempt to determine their degree of relationship, and to ascertain their lineage.* In the case of many cultivated plants, we know that some of them have descended from others; we can trace their history, and we know their pedigree. We infer a similar genealogy for plants whose history we do not know. Our inferences are based upon the presence and

co-existence of the marks or characters already mentioned, and on a just estimate of their value according to the scale of values before explained. On this supposition the number of species (not of individuals) was less at one time than it is now: some of the species have in past times, as they are doing now, given origin to varieties. Some of these latter have perished, the circumstances under which they originated have altered, and there is an end to the variety. Others again better adapted to exist under new and altered circumstances have become invested with a greater degree of permanence, and have taken rank as species. Species are presumed to have originated in the manner just indicated from preexisting species, just as individuals owe their origin to their parents; and moreover, species are being formed constantly at the present time in the same way. An individual plant varies: if the variation is one not likely to ensure the welfare of the individual, it disappears; if, on the other hand, the variation be serviceable, if it enable the plant to hold its own against, or to displace, its competitors, if it allow the plant to live under altered circumstances or under different conditions, the variation becomes, relatively speaking, permanent, and a species is produced, retaining its characters or marks comparatively unchanged so long as the conditions of its existence remain unchanged. It should be borne in mind, however, that these statements are not to be taken as absolutely correct, but as nearly so as the present state of our knowledge will allow.

The two main groups are the Dicotyledons and the

Monocotyledons (see p. 120). These two main divisions are subdivided into classes and sub-classes; these into cohorts, orders, genera, and species, the latter consisting of individuals liable to variation. We can only indicate the general nature of some of these groups by referring to the following table representing the arrangement usually followed in this country, and in which will be found all the orders of which representatives are described at any length in the foregoing pages; for others of which incidental mention only is made the reader should refer to the index.

Phanerogamia (Flowering plants reproduced by seeds containing an embryo).

- Division 1. ANGIOSPERMIA (ovules enclosed within an ovary).
  - Class 1. Dicotyledones, see p. 120.
    - Series 1. *Polypetalæ* (Flowers with free petals).
      - Sub-class 1. THALAMIFLORÆ (stamens springing direct from the thalamus).
        - Order. Cruciferæ, see p. 46.
        - Hypericaceæ, see p. 67.
        - etc., etc.
      - Sub-class 2. CALYCIFLORÆ (stamens partially inseparate from the calyx).
        - Order. Leguminosæ, see p. 52.
        - Rosaceæ, see pp. 35, 61.
        - Crassulaceæ, see p. 75.
    - Series 2. *Gamopetalæ* (Flowers with inseparate or coherent petals).
      - Order. Compositæ, see p. 80.
      - Oleaceæ, see p. 42.
    - Series 3. *Apetalæ* (Flowers without petals).
      - Order. Ulmaceæ, see p. 14.
      - Cupuliferæ, see pp. 113, 124.
      - Salicaceæ, see pp. 4—8.
      - etc., etc.

Class 2. Monocotyledones, see p. 121.
Sub-class 1. SPADICIFLORÆ (Flowers on a spadix).
Order. Aroideæ, etc.
Sub-class 2. PETALOIDEÆ (perianth coloured).
Order. Liliaceæ, see pp. 17—29.
Orchidaceæ, see p. 87.
etc., etc.
Sub-class 3. GLUMIFLORÆ (perianth consisting of green

Order. Gramineæ, see p. 99.
etc., etc.
Division 2. GYMNOSPERMIA (ovules on a flat scale).
Order. Coniferæ, see p 111.
Cryptogamia (Plants reproduced by spores which are not enclosed within a seed).

The systems of classification we have alluded to are styled natural, because an attempt is therein made, with more or less success, to group plants naturally, or according to what is considered to be the greatest amount of resemblance, or to the nearness of their kinship. Many circumstances, and especially our imperfect knowledge, prevent us from ever hoping to attain to absolute perfection in this matter, but at the same time every new fact gained is a step in advance. Artificial systems have no such high aim; practical convenience is here the sole object, and strict scientific accuracy is often sacrificed to expediency. The Linnæan system, founded on the number and relation of the stamens and pistils, was the most celebrated of all these artificial systems; but it is now obsolete by reason of the enormous number of discoveries since the time it was promulgated and many of which cannot conveniently be sorted into their places in the Linnæan arrangement. Nevertheless, the system in question is still useful to

beginners, though what is called the analytic system is now in more general use. In this, as in all artificial plans, the object is to ascertain the name and position of any given plant, without reference to its lineage or its conformation: the object is attained by presenting to the student a series of contrasted characters, of which he selects that which is possessed by the plant he is examining, and rejects the others. The process is repeated till at length, by the constant disregard of marks, which do not agree with those of the plant he wishes to know the name of, he arrives at the desired information. We may illustrate this by putting the table at p. 155 into the analytic form—

1	Plants producing seeds (Flowering plants)	2
	Plants producing spores (Cryptogamia)	
2	Seeds within an ovary (Angiospermia)	3
	Seeds on flat scales (Gymnospermia)	
3	Embryo with two seed-leaves (Dicotyledons)	4
	Embryo with one seed-leaf (Monocotyledons)	6
4	Flowers with free petals (Polypetalæ)	5
	Flowers with united petals (Gamopetalæ)	Corollifloræ.
	Flowers without petals (Apetalæ)	Incompletæ.
5	Stamens springing from the thalamus	Thalamifloræ.
	Stamens inseparate from the calyx	Calycifloræ.
6	Flowers on a spike or spadix	Spadicifloræ.
	Flowers not on a spadix	7
7	Perianth petaloid	Petaloideæ.
	Perianth glumaceous	Glumifloræ.

The above will suffice to illustrate the principle of the analytic system without carrying it out into further

details. The list of fruits on p. 112 is constructed on the same principle.

In 'Floras,' or books devoted to the description of the plants of any country or district, the plants are arranged in orders, genera, species, etc, as before explained, and a description of each species, each genus, and each order is given. It is not often necessary to give a complete description, as that is a lengthy and a tedious process, and is not essential. In most cases all that is required is such a description as shall be sufficiently complete to enable the pupil to distinguish any particular species, or any genus, from any other he is likely to meet with. Thus in the case of Willows or Roses it is not necessary (except in special works destined more particularly for advanced botanists) to give full descriptions of the hundreds of species those genera contain. The generic description is supposed to embrace all the marks common to all the species; the specific description comprises only those points peculiar to the species. In this manner a great amount of unnecessary repetition is avoided. A very little practice will teach the pupil that some points are of much greater consequence than others, as already explained; and not only this—he will speedily find that the distinguishing marks which are important in one group are not so in others. This kind of knowledge can only be gained by practical experience; but with a view to assist the pupil, and direct him generally as to what to look for, we subjoin the following directions, which will draw his attention to most of the important differences between plants.

The main points to be regarded in the case of the—

ROOT are its	Position.
	Duration—annual, perennial, etc.
	Consistence—fleshy, woody, etc.
	Direction—vertical, oblique, etc.
	Form—cylindrical, globose, etc.
	Branching—mode and degree of.
	Surface—smooth or rough, etc.
	Size.
	etc.
STEM.	Duration.
	Consistence.
	Size.
	Form.
	Surface.
	Direction.
	Branching.
	etc.
LEAF.	Position.
	Stalked or sessile.
	Stipulate or exstipulate.
	Composition—simple or compound.
	General form.
	Outline.
	Base (part nearest to the stem).
	Apex (part furthest from the stem).
	Margins.
	Venation.
	Surface.
	Texture.
	Colour.
	Size.
	etc.
INFLORESCENCE.	Position.
	Direction.
	Branching.
	Number of flowers.
	Order of opening.
	Proportion to leaves.
	Duration.
	etc.

PERIANTH, CALYX, AND COROLLA.
Construction.
Relative position.
Freedom.
Inseparation (adhesion, cohesion).
Form.
Direction.
Surface.
Venation.
Colour.
Odour.
Size—relative and absolute.
Duration.
etc.

The individual parts of the flower must be treated as so many leaves.

STAMENS. Position.
Form.
Arrangement.
Direction.
Size—absolute and relative.
Independence.
Union.
etc.

ANTHER. Mode of attachment to the filament.
Relative size.
Form.
Mode of opening.
etc.

PISTIL. Number of carpels.
Independence.
Union.
Relative position.
Arrangement.
Form.
Sutures.
Partitions.
Cavities.
Placentation.
etc.

The remaining portions of the plant must be examined and described in a similar manner.

CHAPTER X.

PLANT-LIFE—Vegetable physiology, its difficulties—Minute structure o plants—Cells, vessels, their structure and contents—Tissues—Epidermis—Root-action—Absorption of fluids and gases, how effected—Osmosis—Rise of the sap—Causes—Diffusion—Colloids and crystalloids—Evaporation from the leaves—Pressure—Capillary attraction—Leaf action—Leaf pores—Interchange of gases through leaves by day and by night respectively—Comparison between plant-life and that o animals—Sensibility in plants—Movements of plants—Contractility—Locomotion—Difference in the nature of the food of plants and o animals—Respiration.

INCIDENTALLY in the foregoing chapters we have alluded to some of the phenomena of plant-life. It would be very undesirable, even if it were possible, wholly to omit all reference to the action of the machinery whose varieties of construction we have attempted to illustrate. At the same time it must be admitted that the study of vegetable physiology—of the plant in action—presents greater difficulties to the beginner than does the investigation of structure.

The subject is not only beset with intrinsic difficulties, but it demands for its successful prosecution instruments and apparatus not often at the command of the beginner. It requires, moreover, a knowledge and practical familiarity with chemistry and physics not usually possessed by the pupil at the outset of his studies. The learner,

therefore, in the majority of cases, has to take for granted the correctness of what he is taught, and has comparatively rarely the opportunity of testing for himself the accuracy of the information given. Moreover, it seldom happens that the teacher has the power of demonstrating to his pupil, except in a superficial way, the phenomena of plant-life. Plant physiology presents greater difficulties than animal physiology, owing to the greater simplicity of vegetable structures. In animals, as in the human body, particular structures are set apart for the performance of particular duties; the lungs have their office to perform, the heart has its separate duty to fulfil, and so with the stomach and the brain. Each of these parts has an internal organisation expressly fitted for the work it has to do. This happens to a much less degree among plants wherein we find organs, such as the leaves, for instance, performing several offices which in the animal world are assigned to different organs. Moreover, the minute or internal anatomy of plants, that which requires for its successful study the use of the compound microscope, is much simpler than that of animals. Parts which have very much the same appearance and conformation, so far as our present means of investigation enable us to determine, nevertheless perform very different offices.

For these reasons we think it is a better plan for the beginner to familiarise himself with the details of plant-conformation before he enters at any length into the study of plant-life. He cannot indeed profitably investigate the latter before he has made himself fairly well acquainted with the former. The pupil must not under-

value the importance of vegetable physiology, as it is of the very highest consequence in enabling us to understand much in the physiology of animals and of the human body which would be unintelligible, or only to be understood with great difficulty, without its aid. With these remarks by way of introduction we propose to lay before the beginner a brief account of the minute structure as well as of some of the more important phenomena of plant-life.

The minute structure of plants consists of *cells*, *tubes*, and *vessels* of various kinds, disposed in various ways. The cells are bladders of membrane, of different shapes and sizes arranged in diverse methods. Within the outer bladder, or *cell-wall* as it is called, are, at least in the young active condition, certain contents, of which the most important for our present purpose is a mucilaginous fluid, called *protoplasm*. All cells, except those which are old, contain more or less of this protoplasm, which is the most important part of the cell so far as functions are concerned. The bladder, or cell-wall, is merely a kind of protecting skin, composed of *cellulose*, a substance akin to starch. Within the cells are formed or deposited various substances, such as albuminous matters, woody material, starch, sugar, oily and fatty materials, colouring ingredients, and the like. The cells so constituted are usually too small to be conveniently seen without the aid of a compound microscope, but the cells of the pith of the elder may be distinguished with an ordinary magnifying glass; those of the pulp of an orange by the naked eye, and these latter indeed may, by a little patience, be separated one from another.

All plants of whatever kind are made up of cells such as those just described, and many have no other structure. In the so-called higher plants, however, we meet with tubes and vessels of various kinds and shapes, differently arranged. Some of these tubes contain woody deposits, as in those which constitute the wood, or the hard shell of stone-fruits; others contain a fine thread or threads coiled up in a spiral manner. A *spiral vessel* is one which contains one or more such threads rolled up within it. Such vessels are found almost exclusively in flowering plants, and constitute, therefore, one of the marks of distinction between them and flowerless plants. By breaking across the leaf-stalk of a strawberry, the fine spiral threads may be drawn out and rendered visible to the naked eye. These tubes and vessels are either elongated cells, or consist of cells placed one over another, the intervening partitions being obliterated. All begin existence as globular cells, and become modified in course of growth.

A mass of cells constitutes what is called a *tissue*—cellular tissue; a mass of vessels constitutes *vascular tissue.* If the cells contain much woody deposit, we speak of the resulting tissue as *woody.* Most plants, moreover, are invested by a skin or bark of some kind. In its simplest and most common condition, this consists of one or more layers of flattened cells. Such layers constitute the *epidermis,* or skin. For our present purpose we need not enter at greater length into the minute structure of plants, but proceed at once to say something as to their functions.

The plant, as we have seen, is, in the majority of cases,

rooted in the earth. In other instances it floats in, or on the surface of water, its leaves are exposed to the atmosphere and to the action of light. Unlike an animal, a plant has no separate mouth and stomach, its skin presents an unbroken surface, or at least exhibits, under natural conditions, no aperture through which solid material, however fine, can enter. Its cells and vessels are closed on all sides, as a rule, and have not, except in rare instances, any direct or immediate communication one with another. In animals there is a continuous alimentary or food-channel, from the mouth to the stomach and intestines. There is also a series of continuous branching tubes devoted to the circulation of the blood, another set of tubes destined for the passage of air into and out of the lungs, and so forth. In plants there is no such series of directly continuous tubes permeating the whole organism. From these facts it may readily be inferred that no solid substance can enter into, or be digested in them. The plant then does not live on solid food, but on that which is liquid or gaseous.

We have now to see whence it obtains its supplies of such nutriment. Rooted in the ground, it has, as a whole, no power of locomotion.* But though this is true of the plant as a whole, it does not apply to the parts of which it is composed. The roots, for instance, grow and extend themselves, and they grow most freely in that direction where food is most abundant or easily got at. Let the pupil examine the roots of a tree growing on the banks of a stream, and see what a leash of

* The exceptions to this rule, though important, are hardly such as the pupil is likely to meet with at the outset of his studies (see p. 174).

fine root-threads are produced if the main roots happen to be immersed in the water. In like manner, the and length [illegible] fro of the branches, bring the leaves into contact with gaseous food, and enable them to avail themselves of it without necessitating the movement of the whole plant from place to place in search of nourishment, as is imperative in the case of most animals.

The roots and the leaves are the chief, and, in many cases, the only feeding organs of the plant. The roots imbibe water from the soil by means of their fine fibrils and root-hairs, the older, thicker portions having no such faculty of absorption, but serving merely as conduits and hold-fasts. The water which exists in and amongst the particles of soil dissolves certain of its ingredients, so that when it enters the roots it is not absolutely pure, but holds in solution a small quantity of gaseous as well as of earthy or mineral substances. These are required in the building up of the plant's substance and in the formation of its secretions. The way in which this solution of earthy and gaseous matters is absorbed into the tissues of the roots has now to be explained. It was shown by Dutrochet (and his observations have been confirmed and extended by many observers, in particular by Graham) that, when a bladder containing some thick liquid, such as syrup, is placed in a vessel of some thinner fluid, such as water, there is a passage of the thinner liquid through the membrane into the interior, so that the thick liquid becomes diluted and the bladder stretched. The pupil can readily see this for himself by procuring a small bladder, partially filling it with thick

syrup, securing the aperture by a string, and then immersing it in a basin of water. After an hour or two he will see that a large quantity of water has passed from the basin into the bladder, and yet there are no visible pores or holes in it. This is precisely what takes place in the case of the roots. The thin solution of earthy matter passes through the membranous walls of the root-cells, there to mingle with the thicker "protoplasm" which they contain. This process of absorption is technically called *osmosis*, or *endosmosis*.

Root-absorption is probably always going on more or less, but it is infinitely more rapid and abundant in spring and summer than at any other time. The fluid when absorbed by the roots receives the name of "sap." We know, by observation and experiment, that this sap rises from the root, passes up the stems, through the branches, and enters the leaves. The rise of the sap in spring is proverbial. If a tree be felled, or if a branch of a vine be cut in spring, the sap is seen to ooze or "bleed" from the lower edge of the cut. In America and Canada the juice of the sugar-maple is collected in this manner, and boiled down for the sake of extracting the sugar it contains. The sap then flows upwards, and it is a matter of great interest to ascertain how it is that such a fluid should ascend against gravity, particularly as there is no pumping apparatus to force it up. The explanations are manifold—several causes co-operate to bring about this result. In the first place, the process of osmosis, begun in the root-cells, is continued in the younger portions of the stem. Moreover, there now comes into operation a process of diffusion, by virtue of

when certain liquids pass through others. Graham, an English chemist, called the thin, readily diffusible liquids, "crystalloids," the thicker, less easily diffused fluids, "colloids," from their gluey or gummy nature, and he demonstrated that the crystalloid fluids pass through and diffuse themselves amongst the colloid ones. When the leaves are fully expanded, another circumstance helps powerfully to promote the rise of the sap, and this is the profuse perspiration or evaporation of watery vapour and fluid from their surface. Let the pupil gather a few leaves and place them under a tumbler exposed to the sun, and he will shortly see a quantity of water condensed on the sides of the tumbler, and which has evaporated from the leaves. This outflow takes place to an enormous extent under favourable circumstances, varying in amount accordingto the pressure, temperature, and moisture of the atmosphere, the quantity absorbed by the roots, and the structure of the leaf itself. There are thus an influx through the root, an upward current through the stem, and an outflow from the leaves. All these act and re-act one on the other; the circumstances that favour the one, for the most part influence the others. If the one or the other be in excess, the plant suffers. If the outflow from the leaves be greater than the influx from the root, the plant withers, and, unless the balance be restored, it will die. If the outflow be stopped while the influx continues, the plant will become unhealthy, and perish if not relieved. The upward current is facilitated by the swaying movement of the trunk and branches caused by the wind, the alternations of pressure and relaxation on

the cells and vessels tending to squeeze the sap upwards, as shown by Mr. Herbert Spencer. Capillary attraction, or that process by which fluids in contact with fine tubes rise in or between them, as the oil rises between the threads of a lamp wick, may also help to account for the rise of the sap in plants, but is probably less potent than the other causes just mentioned.

We have now traced the current of sap from the root to the leaf, and in so doing have necessarily adverted to some of the principal duties fulfilled by the root, stem, and leaf. The leaves, however, are not merely concerned in the evaporation of water, they have, as both feeding and breathing organs, other very important duties to perform connected with the absorption and emission of gases. The skin of the leaf, especially on its lower surface, is perforated here and there by small breathing holes, or *stomata,* which contract or open, according to the more or less moist state of the atmosphere, and perhaps the intensity of the light. Through these pores liquids and gases enter and escape.

It is found by chemical research that the greater part of a plant consists of carbon and water, to which are added sundry mineral ingredients, and others containing nitrogen, the latter element playing an important part in the protoplasm and in the albuminoid contents of the cells. As we have seen, the plant derives some of these ingredients from the soil by means of its roots; it can, for instance, procure by their aid water, certain gases, including carbonic-acid gas and ammonia, various mineral ingredients, and salts, including nitrates, but for its supply of gaseous food it is mainly dependent on the leaves.

These organs not only allow of the outflow of water, but they drink it in under certain circumstances like the roots. This is shown by the manner in which a withered plant regains its firmness when syringed. Still it is probable that the most important office of the leaves consists in the interchange of gases. The air contains a quantity of carbonic acid gas (a compound of carbon with oxygen) and upon this, with ammonia (consisting of nitrogen and hydrogen) and water (oxygen and hydrogen), the plant feeds. In daylight, when the leaves are exposed to the sun, they are engaged in imbibing the carbonic acid gas from the air, and in utilising it. They store up the carbon, which is needed for their tissues and secretions, and they set free the oxygen into the air. In this manner plants, while engaged in feeding by means of their leaves, act in an opposite way to animals The latter, when breathing, avail themselves of the oxygen of the air, and give out from their lungs carbonic acid and other gases. Thus, what is of no service to the one, is essential to the other, and *vice versâ.* Plants, as they feed, fit the air for the respiration of animals ; animals, as they breathe, yield up to the atmosphere the ingredients needed for the food of plants. The pupil may prove for himself the emission of oxygen gas from plants by a very simple experiment. He should procure some leaves, place them in a tumbler half filled with water, invert over the mouth of the tumbler a funnel of glass, closing its aperture by a small cork, and place the apparatus in a window exposed to the sun. Shortly bubbles of gas will be observed on the leaves ; the gas so formed will accumulate, and ultimately fill the funnel.

If now the cork be removed, and a lighted match be applied to the end of the tube, the match will burn with increased brilliancy, or if its flame be previously put out, and the wood be in a glowing state, it will again burst into flame when placed near the aperture of the funnel, thus proving the existence of oxygen gas. At night, or if exposed to darkness, the leaves cease to feed; but as they continue to breathe they set free carbonic acid, and, to some extent, therefore, render the air impure for animal respiration.

As a result of the interchange of gases, of which we have been speaking, growth, the formation of new tissues, and the production of various secretions, &c., take place. It is the green colouring matter of the leaf, the *chlorophyll*, which is the chief agent in the breaking up of carbonic acid, the setting free of oxygen, and the fixing of the carbon under the influence of sunlight. It is supposed by chemists that the gradual reduction in the quantity of oxygen may account for the formation of starch, various vegetable acids, and other secretions, containing relatively less and less oxygen, till ultimately such substances are formed as turpentine, resins, or other so-called hydro-carbons, which consist of hydrogen and carbon in admixture, and into the composition of which little or no oxygen enters. The further development of this portion of the subject is a matter for the chemist rather than the physiologist, and may therefore with propriety be passed over in an elementary book of this character.

The remaining phenomena of plant-life may perhaps be best illustrated by continuing our comparison of them

with those manifested in the animal kingdom. Anatomically, there is no line to be drawn between plants and animals; the lowest plants and the lowest animals are so much alike, that it often happens that the naturalist is unable to say to which group a particular organism may belong. Physiologically, however, there are differences, as we shall now attempt to show. Regarded as living beings, both plants and animals feel, feed, digest, breathe, grow, move, and increase in numbers. It is in their mode of fulfilling these functions that the chief differences between the two kingdoms consist.

Plants feel—they respond to stimulus. They may not be able to communicate their sensations as some animals do, but many of the latter are not a whit more communicative on this point than a sea-weed. We, as members of the animal kingdom, feel the impact or contact of other substances. Light, heat, cold, electrical disturbances, chemical substances, all make us feel; and if the sensation be of a disagreeable nature, we get away from the source of irritation as fast as we can; but if the sensation be pleasant, we endeavour to repeat it.

In the case of plants the great stimuli are light and heat. These exert a powerful influence on the protoplasm, as has been shown again and again. The protoplasm of plants and the "sarcode" of animals have precisely similar properties. The action of light in giving rise to motion both in plants and animals is well seen in the lower organisms, which, if green, that is if containing chlorophyll, move towards the light; but if they have no chlorophyll, light has no special influence in determining their movements. Hence the motion

witnessed would seem to be dependent on the decomposition of carbonic acid gas and the elimination of oxygen, which takes place under such circumstances as already explained. The protoplasm which lines the cells has *contractile* powers, and these contractile powers are, as we have seen, set in action by the stimuli of light or heat, and probably by electricity.

There are other movements in plants evincing sensibility. Human beings are apt to blush on the occasion of sudden strong emotions, and this blushing is due to a sudden *turgescence* of the minute vessels induced by their momentary dilatation. Plants execute movements, due, like blushing, to varying amounts of turgescence. In most active vegetable cells "currents" of fluids may be observed. These currents are not entirely dependent on contraction of the protoplasm, but on the varying degrees of absorption manifested in it. If one portion suddenly exerts a great power of absorbing water, there is a corresponding flow to meet the demand. Hence imbibition causes turgescence, and the turgescence gives rise to the formation of currents in individual cells. When a number of such cells are closely packed together, and are influenced in the same way, not only is there a flow in the cells individually, but there is a rush of fluid from cell to cell and consequently a movement throughout the whole organ thus affected. In this way the opening and closing of flowers, as well as the folding and unfolding of leaves, may to some extent be accounted for.

The curious movements of sensitive plants are to be explained in a similar manner by the swelling of certain

of their tissues, this turgescence being stimulated or set in action by certain stimuli and checked by others.

Climbing plants and some tendrils exhibit two different kinds of movements—the one a spontaneous revolving power manifested in young active shoots, in some plants in one direction, in others in the contrary. The object of these revolutions is to allow the stem to attach itself to some support round which it may twine. How they are effected is not understood; they seem to be spontaneous, and not under the influence of external conditions. The movements of most tendrils, however, are directly excited by contact. A slight touch causes them to move. In Orchids, as we have seen (p. 95), and in many flowering plants, we have displacements taking place in the stamens, in the style, or in the pollen itself, these movements being apparently dependent on contraction of the protoplasm, or on varying hygrometric conditions. Hence, then, so far as feeling goes, if we admit sensitiveness as the equivalent of sensation, we cannot deny that a plant possesses the same faculty as an animal.

If we take locomotion or the power of translation from place to place, once considered distinctive of animals, we shall find it is possessed by vegetables as well. This is seen in certain organs of reproduction called *zoospores* and in the *antherozoids* of algæ and other cryptogamous plants. The movement, in all likelihood, depends on the agitation of the fine *cilia* or threads with which these organisms are bedecked: but we are still ignorant as to the cause that excites the vibration of the cilia.

As regards the diet of plants and animals respectively, we have already seen that the former cannot take in solid materials. It is far different with animals, the most humbly organised of which have the power, in some way or another, of introducing solid food into their interior, and of digesting it. The nutriment of animals differs, therefore, from that of plants, physically. Another difference consists in its chemical nature. An animal not only feeds on solid food, but that food is of organic nature; in other words, the animal enjoys the privilege of eating its fellow creatures, dead or alive. A plant is, however, not confined absolutely to inorganic matter for its diet. It thrives upon and indeed requires organic matters, or the *products* of organic matters; but they must, as a rule, be *waste* products, not living. Plants manured with purely mineral ingredients not only do not thrive, but they are often worse off than others of the same kind that are not manured at all. It is pretty clear, then, that plants cannot live solely upon inorganic materials. Our everyday experience shows us, on the other hand, that animals cannot live exclusively upon organic materials. If we want to feed a plant so as to ensure the greatest amount of vigour, we give it organic food in the shape of manure. If we want to digest our own food we take a sufficiency of salt, we give chalk to our chickens, lime and iron to our ricketty children, and steel to our pallid young ladies.

The gaseous food of plants has already been alluded to. It remains, to notice the breathing process in plants and animals respectively.

Respiration is an interchange of gases, and this inter-

change is effected in animals by means of cavities, lungs, gills, or tracheæ; but whatever shape the breathing apparatus assumes, the ultimate result is that the air inspired or expired is passed through a membrane. We know from the researches of Graham that membranes act the part of filters, allowing some gases to pass and retaining others, according to the nature of the filter and of the gases.

In the lower animals, and in plants, we have no special lungs, or gills. There are tracheæ in plants, but they are not specially subservient to respiration and there is covering the whole surface a thin membranous cuticle or epidermis. This cuticle acts as a filter, allowing the gases to pass by diffusion into or out of the leaf. In addition there is a direct passage of gases through the stomata. In a general sense, then, the mechanism of respiration is the same in animals and plants. The movements of the leaves by the wind, probably serve the same purpose as that fulfilled by the muscles of respiration in the case of an animal.

The gases exhaled and inhaled during the breathing process are the same in both instances. Constantly there is an absorption of oxygen and a disengagement of carbonic acid gas. The elimination of oxygen by the green parts of plants is, as before stated, not so much an act of respiration as of digestion.

The plant is thus constantly exposed to two antagonistic forces—the one tending to build up, the other to destroy the organism. At certain epochs in certain organs, and if kept in darkness, the plant invariably emits the same gases as an animal does. So also,

under the influence of green light, the ordinary action of leaves is partially inverted.

In alluding to the effect of light on the disengagement of oxygen gas, it should, however, be remembered that the light can be and is fixed or stored in the plant, so as to operate for a time even in complete darkness.

The reproductive process in plants has been alluded to in former chapters (see pp. 7, 53, 95), as also the multiplication by means of buds (pp. 17, 24). The former results in the production of a new cell, which becomes the embryo; the latter is essentially a segmentation, or repeated subdivision of old cells.

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Latin names of plants, genera, and orders are in italics. The numbers attached to the technical terms indicate the pages where an explanation will be found.

THE END.

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PREFACE.

FROM the experience of several years as a lecturer, the compiler of the following pages has arrived at the conclusion that one of the greatest difficulties in the way of those beginning to study Botany arises from the profusion of details usually presented to their notice at the outset. The most zealous students not unfrequently chafe at the irksome task of making themselves acquainted with a series of abstract propositions, couched in harsh unfamiliar language, and whose significance they are unable to appreciate. An attempt has therefore been made in the following chapters to correlate these details from the first, and to give the pupil an interest in them, by making manifest to him their importance as illustrations of the principles of plant-construction. The simplest flowers have been chosen as examples in the first instance; afterwards others of more complicated construction have been selected. An effort has been made in each case to show how and why the various modifications have been brought about. The life-history of the several plants has been incidentally touched on, and occasional hints have been furnished with a view to show the real aim and scope of botanical science, concerning which many students hold far too limited views.

Here and there the writer has deviated slightly from the conventional method of describing certain structures met with in plants. He has been impelled to do so from the feeling that it is hopeless to expect any real progress to be made in scientific botany so long as pupils are taught to trust to superficial appearances, rather than to investigate the origin and mode of growth of plants; in other words, to consider the "system" as of more consequence than the plants composing it.

The illustrations selected are all of them easily to be procured in gardens or fields, and they are described with reference to the season of the year; those mentioned in the earlier chapters flowering in spring, those in the following ones at a later period.

It may be added that nothing like original or exhaustive treatment of the subject has been attempted The object of the writer has been simply to endeavour to smooth the path for the beginner, to suggest to him accurate ideas as to the scope of the science, and to facilitate his use of more important works.

It should be stated in conclusion, that the substance of the following chapters appeared originally in the columns of the "Gardeners' Chronicle." To the proprietors of that journal the writer has to tender his thanks for permission to make use of the illustrative woodcuts prepared by Mr. Worthington Smith. Other cuts have been placed at the writer's disposal by the publishers.

April, 1872.

BOTANY FOR BEGINNERS.

BOTANY FOR BEGINNERS:

AN INTRODUCTION TO

THE STUDY OF PLANTS

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